**Technical Report 1669**
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# A Three-Dimensional Geoacoustic Model for the Catalina Basin

## Version 1.0

R. T. Bachman

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# ADMINISTRATIVE INFORMATION

This work was performed under project SUB6 by R. T. Bachman of the Acoustic Branch, Code 541, of the Naval Command, Control and Ocean Surveillance Center, RDT&E Division, San Diego, CA.

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# SUMMARY

## OBJECTIVE

Develop a three-dimensional geoacoustic model for the Catalina Basin.

## RESULTS

A three-dimensional database containing water depth, sediment thickness, surface and basement rock type, and surface sediment mean grain size is provided, which, when combined with generic sediment and rock geoacoustic properties (also provided) produces a geoacoustic description of the Catalina Basin. Mean grain size is used as an index to acoustic properties. The database is gridded at 15 seconds of latitude and longitude.

## RECOMMENDATIONS

1. Incorporate refinements to existing information as they become available.
2. Incorporate thinly sedimented areas into the database. For instance, Emery Knoll and the flanks of San Clemente and Catalina Islands are known to be sediment-covered. While probably acoustically significant, this cover is too thin to appear on standard sediment thickness maps.
3. Investigate a way to accommodate fluctuations in mean values. Geoacoustic properties are modeled as smooth functions of depth below the sea floor. This is a reasonably good approximation. However, fluctuations about the mean values exist in nature and are probably significant acoustically.
4. Resolve anomalies indicated in the database. Relatively thick deposits of coarse sediment are indicated in the database (e.g., up to 0.4-s two-way travel time or about 350 m). It is doubtful that sand has accumulated to such a thickness. These areas occur as small patches along the flanks of Catalina and San Clemente Ridges.

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# INTRODUCTION

## GEOACOUSTIC MODELS

A geoacoustic model is a description of the sea floor detailing sediment and rock properties of importance in sound propagation, including the variations of those properties with depth in the seabed. The properties considered here are speed and attenuation of compressional and shear waves, and density. Also required are true water depth and profiles of seawater sound speed and density.

The first step in constructing a geoacoustic model is to assemble information on the physical and elastic properties and thickness of the sediments and rocks in the study area. Rarely is enough information available, so recourse is made to predictive methods, generally those of Hamilton (e.g., 1980). These techniques are discussed in appendix A.

## CATALINA BASIN

Catalina Basin is an elongated, faulted trough, bordered by the abrupt escarpments of Catalina Island and ridge to the north and northeast, and San Clemente Island and ridge to the southwest. The basin floor itself is quite flat (see figure 1).

There are no drill holes in Catalina Basin, so what is known and believed about the geology is based on samples of surface materials (sediment cores and rock dredge hauls), studies of Catalina and San Clemente Islands, and seismic reflection profiles. Seismic reflection profiling uses a high-energy, low-frequency sound source to image the sea floor and buried reflecting horizons. Figure 2 shows a seismic reflection record from Catalina Basin. Depth to the sea floor and buried reflectors is measured in terms of two-way sound travel (reflection) time.

Basin-fill consists of soft and semiconsolidated turbidite sediment over sedimentary rock (mudstone and shale). The contact between the turbidites and sedimentary rock is an unconformity (a surface representing a period of nondeposition or erosion). The island ridges are sedimentary, volcanic, and intrusive igneous rock (e.g., granite). The ridges and their flanks are either barren of sediment or have a thin veneer of unconsolidated, relatively coarse material. Figure 3 is a surface geologic map of the Catalina Basin area.

A gridding approach was adopted for organizing the data. The area bounded by 32°50′N, 33°35′N, 118°W, and 119°W was divided into rectangular grid cells, each cell being 15 arc-seconds on a side. The cells are centered on 7.5, 22.5, 37.5, and 52.5 seconds of latitude and longitude. This results in a grid of 240 cells in the east-west direction by 180 cells in the north-south direction. This became the framework for a geographic database containing cell indices, true water depth, sediment thickness, basement rock type, sea floor rock type (if present), sea floor sediment name (when used to estimate sediment properties), and surface sediment mean grain size. The resulting database of water depth, sediment thickness, and surface geology is used along with generic geoacoustic models discussed below to construct a model specific to each grid cell.

The organization of the geographic database is discussed in appendix B. Sediment thickness is discussed in appendix C, water depth in appendix D, and mean grain size in appendix E. Appendix F gives literature data on sediment and rock samples. Appendix G gives temperature, salinity, and sound speed data useful for constructing a geoacoustic model.

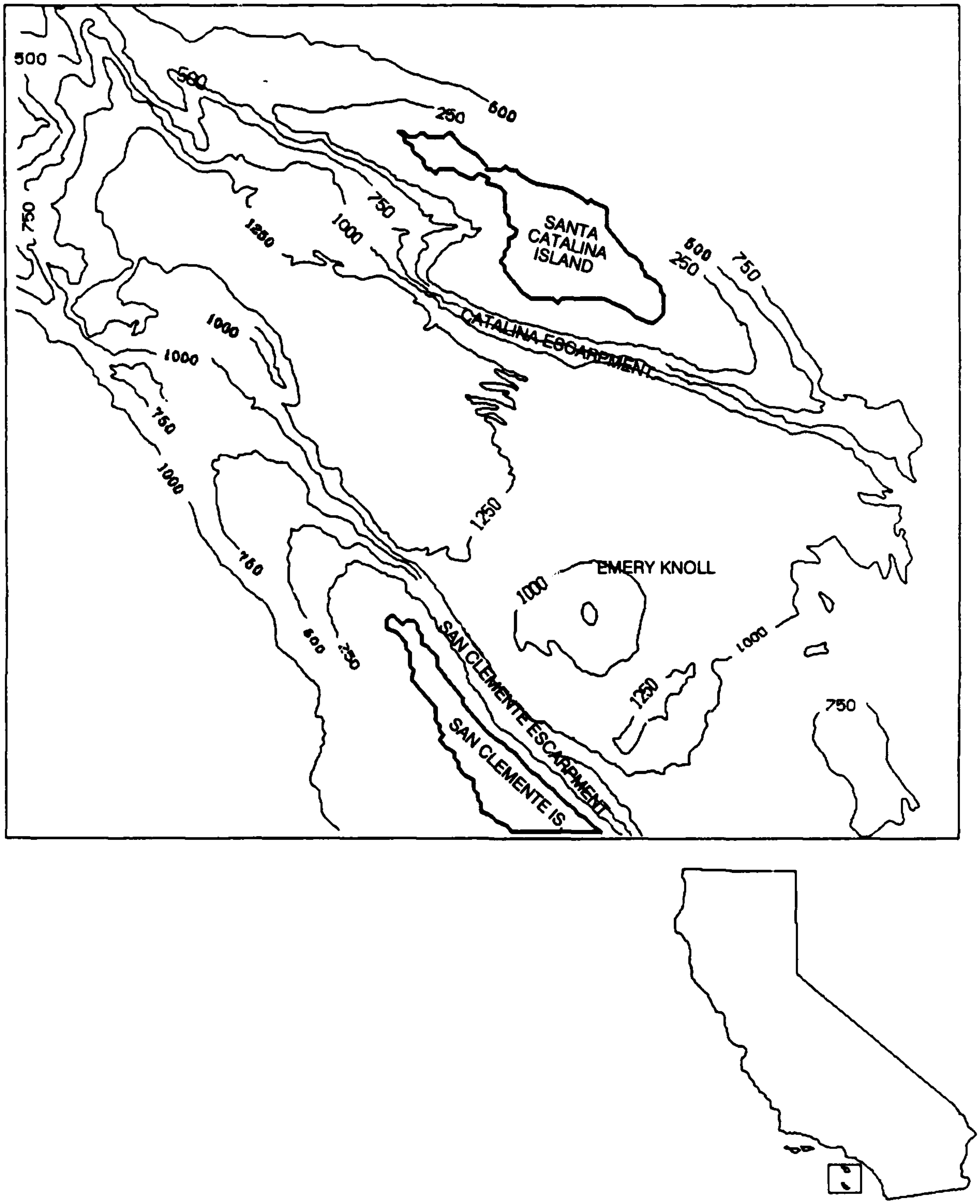



Figure 1. Catalina Basin and environs. Depth contours in meters from U.S. Coast and Geodetic Survey chart 1206N–15. Latitude limits of the database and figure are 32°50′N and 33°35′N; longitude limits are 118°W and 119°W.

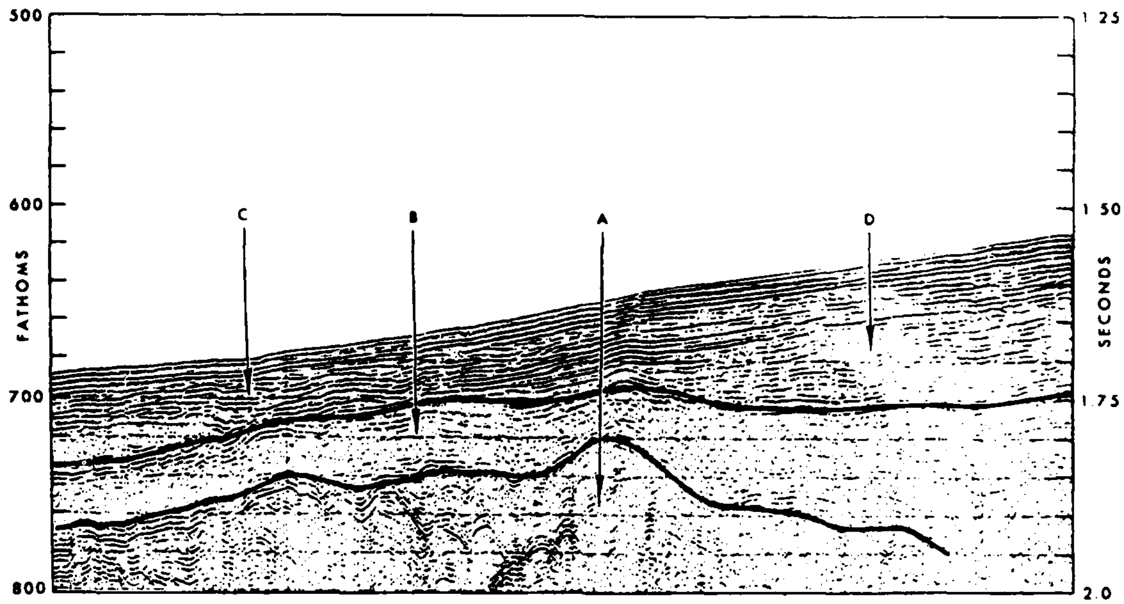
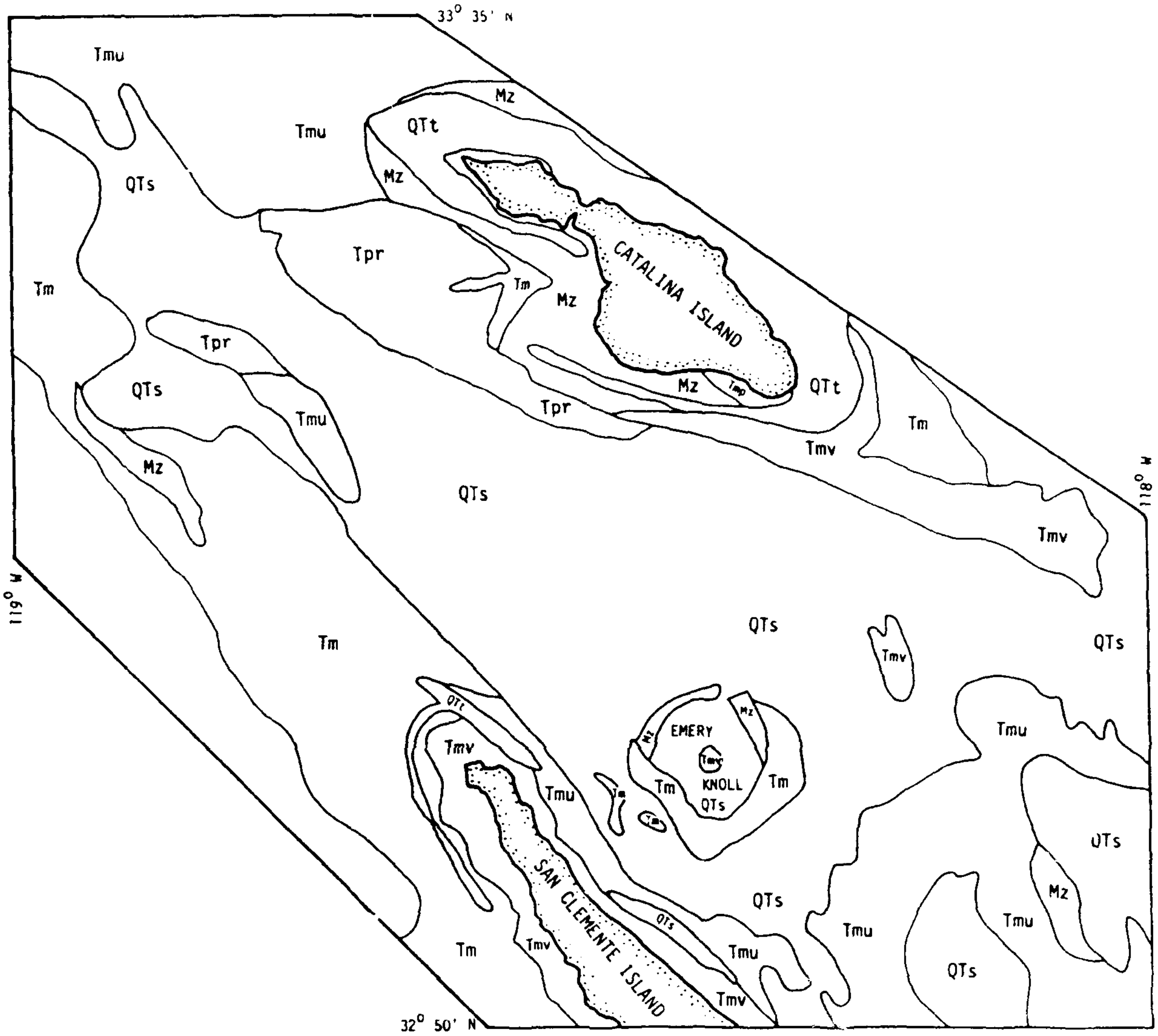



Figure 2. Seismic reflection profile running northwest (to the left) through Catalina Basin. From Moore, 1969, plate 5. The interpretation is Moore's. "A" points to older, folded sedimentary rocks. "B" points to slightly folded sediments. "C" points to recent sediment. "C" also marks a buried submarine channel, as does (probably) "D." The vertical scales are seconds of two-way sound travel time and fathoms (assuming a seawater sound speed of 4800 feet per second).




QTs Sediments and sedimentary rocks of Quaternary and Tertiary (Pliocene and Miocene) age
QTt Terrace deposits of Quaternary and late Tertiary (?) age
Tpr Sedimentary rocks of early Pliocene and late Miocene age
Tm Sedimentary rocks of Miocene age
Tmv Volcanic rocks of Miocene age
Tmu Undifferentiated volcanic and sedimentary rocks of Miocene age
Tmp Plutonic rocks of Miocene age
Mz Metamorphic rocks of pre-Late Cretaceous age

Figure 3. Geologic map of the Catalina Basin, generalized from Greene and Kennedy (1986). In the explanation above, rock units are arranged from youngest at the top to oldest at the bottom.

# SEDIMENT GEOACOUSTIC PROPERTIES

Generic geoacoustic models for coarse and fine sediment follow. The division between "coarse" (sand and coarse silt) and "fine" (fine silt and clay) sediment is a mean grain size of 4.5 phi units (grain size in phi units = $-\log_2$ [grain size in millimeters]; this is roughly the mid-way point between silty sand and sandy silt in table I of Hamilton and Bachman, 1982). The models are modified according to the water depth and sediment thickness in a grid cell. The model consists of sound speed, density, shear wave speed, sound attenuation, and shear wave attenuation presented as functions of depth below the sea floor. As shown in appendix A, smooth depth functions are only approximations to reality.

The functions for fine-grained sediment are valid to 950 m below the sea floor. This is equivalent to a two-way sound travel time of 1 s, the greatest thickness of unlithified sediment encountered in the basin. Coarse-grained sediment functions are valid to about 50 m at least; for the present they must be extrapolated to accommodate anomalous areas of thick sand.

## FINE-GRAINED SEDIMENT (MEAN SIZE = 4.5 PHI OR FINER)

### Sound Speed

The equations for sound speed are

$$R = 1.296 - 6.01e{-2}\ Mz + 2.83e{-3}\ Mz^2 \tag{1}$$

$$Vp(Z) = Vp(0) + 1.227\ Z - 4.73e{-4}\ Z^2 \tag{2}$$

where Vp is in m/s and Z is depth below the sea floor in m (Hamilton, 1985, table II). Vp(0) is the product of the sound speed ratio R and sound speed in the bottom water. R is computed using mean grain size from the database. The utility of, and rational for, the ratio R is discussed in appendix A.

### Density

The equations for density are

$$rho(0) = 2.38 - 1.725e{-1}\ Mz + 6.89e{-3}\ Mz^2 \tag{3}$$

$$rho(Z) = rho(0) + 1.395e{-3}\ Z - 6.17e{-7}\ Z^2 \tag{4}$$

where rho is in $g/cm^3$, Z is depth below the sea floor in m, and Mz is mean grain size in phi units. Equation 3 is from Bachman (1985, table I), and equation 4 is from Hamilton (1976a, table 5).

### Shear Wave Speed

The equations for shear wave speed are

$$Vs(Z) = Vp(Z)\ /\ K(Z), \text{where} \tag{5}$$

$$K(Z) = 12.41 - 0.2316\ Z \qquad (0 <= Z <= 29.6) \tag{6}$$

$$K(Z) = 6.02 - 0.0155\ Z \qquad (29.7 <= Z <= 131.2) \tag{7}$$

$$K(Z) = 4.21 - 0.0017\ Z \qquad (131.3 <= Z <= 1000) \tag{8}$$

In these equations (derived from Hamilton, 1979, figures 1 and 2), Z is depth below the sea floor in m, Vp is sound speed at Z, and Vs is shear speed in m/s.

**Sound Attenuation**

The equation for sound attenuation is

$$Z < 775 \text{ m}:$$
$$kp(Z) = 1.46e{-2} + 9.088e{-5}\ Z - 2.285e{-7}\ Z^2 + 1.336e{-10}\ Z^3 \tag{9}$$

$$Z >= 775 \text{ m}:$$
$$kp(Z) = 0.01 \tag{10}$$

where kp is in dB/m/kHz, and Z is in m. This is the mean of the curves in Mitchell and Focke (1980, figure 11). To obtain attenuation in dB per meter of travel, multiply kp by frequency in kHz.

**Shear Wave Attenuation**

The equations for determining shear attenuation are

$$K = (17.3 \text{ dB/m/kHz}) / kp(0)\text{, and} \tag{11}$$
$$ks(z) = K\ kp(Z) \tag{12}$$

where ks is in dB/kHz/m, kp is compressional attenuation, and 17.3 dB/m/kHz is a shear attenuation value for mud published by Warrick (1974). The method follows Hamilton (1980, p. 1331-1332). To obtain attenuation in dB per meter of travel, multiply ks by frequency in kHz.

**COARSE-GRAINED SEDIMENT (MEAN SIZE COARSER THAN 4.5 PHI)**

**Sound Speed**

The equations for sound speed (after Hamilton, 1976b) are

$$Vp(Z) = K\ Z^{0.015}\text{, where} \tag{13}$$
$$K = Vp(0) / 0.05^{0.015}\,. \tag{14}$$

Z is depth in the sediment in meters. Vp(0) is computed as above (equation 1 and text). The constant K is evaluated (equation 14) by assuming that a surface sediment sound speed is measured at a depth of 0.05 m (see Hamilton, 1975, p. 24).

**Density**

The density of sand is relatively insensitive to the burial depths considered here. Therefore, sand density will be taken as constant with depth:

$$rho = 2.38 - 1.725e{-1}\ Mz + 6.89e{-3}\ Mz^2 \tag{15}$$

(see the remarks for equation 2 above).

**Shear Wave Speed**

The equation for shear speed (after Hamilton, 1976b) is

$$Vs(Z) = K\,Z^{0.25}\text{, where} \quad (16)$$

$$K = Vs(0) / 0.05^{0.25}\text{, and} \quad (17)$$

$$Vs(0) = Vp(0) / 31.4\,. \quad (18)$$

Z is depth in the sediment in meters. The constant K is evaluated (equation 17) by again assuming that surface sediment shear speed is at a depth of 0.05 m. Shear speed at the sea floor (equation 18) follows Hamilton (1979, table II).

**Sound Attenuation**

Surface sediment sound attenuation as functions of mean grain size (Mz) are

$$0 < Mz <= 2.5: \quad kp(0) = 0.230 + 0.026\ Mz \quad (19)$$

$$2.5 < Mz <= 4.1: \quad kp(0) = -0.158 + 0.181\ Mz \quad (20)$$

$$4.1 < Mz <= 4.5: \quad kp(0) = 2.703 - 0.517\ Mz \quad (21)$$

The variation of sound attenuation with depth is

$$kp(Z) = kp(0)\,Z^{-1/6} \quad (22)$$

Equations 19 through 22 are from Hamilton (1980, figure 19, p. 1330).

**Shear Attenuation**

A value of 13.2 dB/m/kHz is assigned to surface shear attenuation (ks(0), dB/m/kHz: Kudo and Shima, 1970; see also Hamilton, 1980, p. 1331). At depth, a simple proportionality between kp and ks is proposed (following Hamilton, 1980, p. 1332):

$$ks(Z) = 13.2\ kp(Z) / kp(0) \quad (23)$$

## BASEMENT GEOACOUSTIC PROPERTIES

The rock types present in the Catalina Basin are

| | |
|---|---|
| Tpr | Undifferentiated sedimentary rocks of early Pliocene and late Miocene age |
| Tm | Undifferentiated sedimentary rocks of Miocene age |
| Tmv | Volcanic rocks of Miocene age |
| Tmu | Undifferentiated volcanic and sedimentary rocks of Miocene age |
| Tmp | Plutonic and hypabyssal rocks of Miocene age |
| Mz | Metamorphic rocks of pre-Late Cretaceous age |

(see figure 3).

### MIOCENE/PLIOCENE SEDIMENTARY ROCKS

Tpr, Tm, and Tmu, taken together, probably correlate with "Unit C" of Ridlon (1968). Where sampled, Ridlon's Unit C is finely crystalline limestone. On San Clemente Island, Miocene sedimentary rocks are predominantly siltstone, shale, diatomite, and limestone (Olmsted, 1958). Following Ridlon (1968, p. 33), an average sound speed of 2300 m/s is assigned to the Mio-Pliocene sedimentary rocks of the Catalina Basin area. The complete geoacoustic model for Tpr, Tm, and Tmu is

$$\begin{aligned} Vp &= 2300 \text{ m/s} \\ Vs &= 885 \text{ m/s} \\ rho &= 2.21 \text{ g/cm}^3 \\ kp &= 0.009 \text{ dB/m/kHz} \\ ks &= 3.4 \text{ dB/m/kHz} \end{aligned}$$

Vs is from Hamilton (1979, table I), density is from Hamilton (1978, figure 1), kp is the average of Mitchell and Focke (1980, figure 11, deep sediment), and ks is from McDonal et al., (1958).

### IGNEOUS AND METAMORPHIC ROCKS

The igneous and metamorphic rock units present are Tmp, Tmv, and Mz. A single, generic model is included for these (from an unpublished study of basalt acoustic basement in the western Atlantic Ocean).

$$\begin{aligned} Vp &= 4500 \text{ m/s} \\ Vs &= 2400 \text{ m/s} \\ kp &= 0.03 \text{ dB/m/kHz} \\ ks &= 0.07 \text{ dB/m/kHz} \\ rho &= 2.58 \text{ g/cm}^3 \end{aligned}$$

## CONSTRUCTING A GEOACOUSTIC MODEL

The construction of a geoacoustic model for a specific location proceeds as follows.

1. Obtain the water depth, surface sediment grain size, and sediment thickness for the desired location from the database. If the sea floor is rock, then select the appropriate model above and skip the remainder of this section.

2. Using water depth, interpolate the appropriate table in appendix G to find the bottom water sound speed and density.

3. Compute sound speed ratio (R) from mean grain size using equation 1.

4. Determine Vp(0) as the product of bottom water sound speed and the sound speed ratio R.

5. Knowing the velocity-depth function (equation 2 or 13) and sediment thickness in seconds of two-way travel time, integrate to find sediment thickness in meters.

6. Compute acoustic properties below the sea floor.

For example, assume that a winter-season model is required for 33°12′37.5″N and 118°35′ 07.5″W. From the database, the depth at this location is 1303 m, sediment thickness is 0.20 s, and mean grain size is 6.39 phi.

Linearly interpolating the winter profile of appendix G, we obtain 1485.0 m/s and 1.0335 g/cm$^3$ for seawater sound speed and density at this depth.

The sound speed ratio (R) computed using equation 1 is 1.028. Multiplying R by 1485.0 m/s yields 1526 m/s as sediment sound speed at the sea floor. The sound speed depth function (equation 2) is

$$Vp = 1526 + 1.227\,Z - 4.73e\text{–}4\,Z^2$$

Integrating until two-way travel time is 0.20 s yields a thickness of 162 m. Equations 3 through 12 yield density, shear speed, and attenuations. Table 1 is an example geoacoustic model for the situation described above.

Table 1. Example geoacoustic model.

| | Z | Vp | Vs | kp | ks | rho |
|---|---|---|---|---|---|---|
| Seawater | 0 | 1485.0 | | | | 1.0335 |
| | 0 | 1526 | 123 | 0.0146 | 17.30 | 1.559 |
| | 1 | 1527 | 125 | 0.0147 | 17.41 | 1.560 |
| | 2 | 1528 | 128 | 0.0148 | 17.51 | 1.562 |
| | 3 | 1530 | 131 | 0.0149 | 17.63 | 1.563 |
| | 4 | 1531 | 134 | 0.0150 | 17.73 | 1.565 |
| | | | | • | | |
| | | | | • | | |
| | 100 | 1644 | 368 | 0.0215 | 25.43 | 1.693 |
| | 101 | 1645 | 369 | 0.0215 | 25.49 | 1.694 |
| Sediment | 102 | 1646 | 371 | 0.0216 | 25.54 | 1.695 |
| | 103 | 1647 | 373 | 0.0216 | 25.60 | 1.696 |
| | | | | • | | |
| | | | | • | | |
| | 159 | 1709 | 434 | 0.0237 | 28.06 | 1.765 |
| | 160 | 1710 | 434 | 0.0237 | 28.10 | 1.766 |
| | 161 | 1711 | 435 | 0.0237 | 28.13 | 1.768 |
| | 162 | 1712 | 435 | 0.0238 | 28.16 | 1.769 |
| Mudstone | 162 | 2300 | 885 | 0.009 | 3.4 | 2.21 |

**NOTES:**

Z = depth below sea floor, m
Vp = sound speed, m/s
Vs = shear wave speed, m/s
kp = compressional wave attenuation factor, dB/m/kHz
ks = shear wave attenuation factor, dB/m/kHz
rho = density, $g/cm^3$

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# APPENDIX A: GEOACOUSTIC MODELING DETAILS

## COMPRESSIONAL WAVE SPEED

Sea floor sediment sound speed is conveniently expressed as the ratio between surface sediment sound speed and seawater sound speed at the sea floor (Hamilton, 1971; Rajan and Frisk, 1992). For a given sediment type, this ratio is constant. Knowing sound speed ratio and the seawater sound speed profile enables a determination of surficial sediment sound speed at any water depth. Sound speed ratio may be estimated from sediment type (Hamilton and Bachman, 1982) or from empirical relationships with other sediment properties (Bachman, 1989; Richardson and Briggs, 1993).

Average profiles of sound speed with depth below the sea floor have been determined for various sediment types by Hamilton (1985). These velocity-depth functions are based mostly on wide-angle seismic reflection methods (Le Pichon et al., 1968; Houtz et al., 1968; Bachman et al., 1983). Seismic velocity-depth measurements from surface ships could not be independently verified until subsurface logging methods were adapted to Deep Sea Drilling Project (DSDP) and Ocean Drilling Project (ODP) drill holes.

Figure A-1 compares the seismic measurements of Bachman and Hamilton from the Ontong Java Plateau (Johnson et al., 1978) with down-hole logging in the same area (Fulthorpe et al., 1989). These results validate seismic sound speed determinations. Figure A-2 compares logging results from the Labrador Sea (Jarrard et al., 1989) with Hamilton's (1979a) prediction for the same sediment type (deep-sea terrigenous turbidites; similar to the fill in Catalina Basin). Figure A-2 shows that Hamilton's methods (based on seismic measurements) reliably predict the average trend of in situ sound speed profiles. Figures A-1 and A-2 also show variations about the trend, which are probably acoustically significant. These might be best modeled statistically as in Gilbert (1980) or Holthusen and Vidmar (1982).

## DENSITY

Lacking measurements, sediment density at the sea floor can be estimated from other measured parameters (e.g., Bachman, 1985; Richardson and Briggs, 1993), or from tables of averages for the various sediment types (Hamilton and Bachman, 1982).

Density-depth functions were discussed by Hamilton (1976). This work was based on laboratory measurements, which were then corrected to in situ conditions using theory and consolidation test results from the geotechnical literature. As with sound speed profiles, confirmation of Hamilton's approach had to await down-hole logging. Figure A-2 shows a sediment density log from ODP hole 646 in the Labrador Sea (Jarrard et al., 1989, figure 1), along with Hamilton's prediction for that sediment type. The average trend is accurately predicted. Again, high-frequency variations are seen.

## SHEAR WAVE SPEED

Hamilton's (1979b) methods of relating shear to compressional wave speeds are used. To my knowledge, no down-hole data are available to test the results.

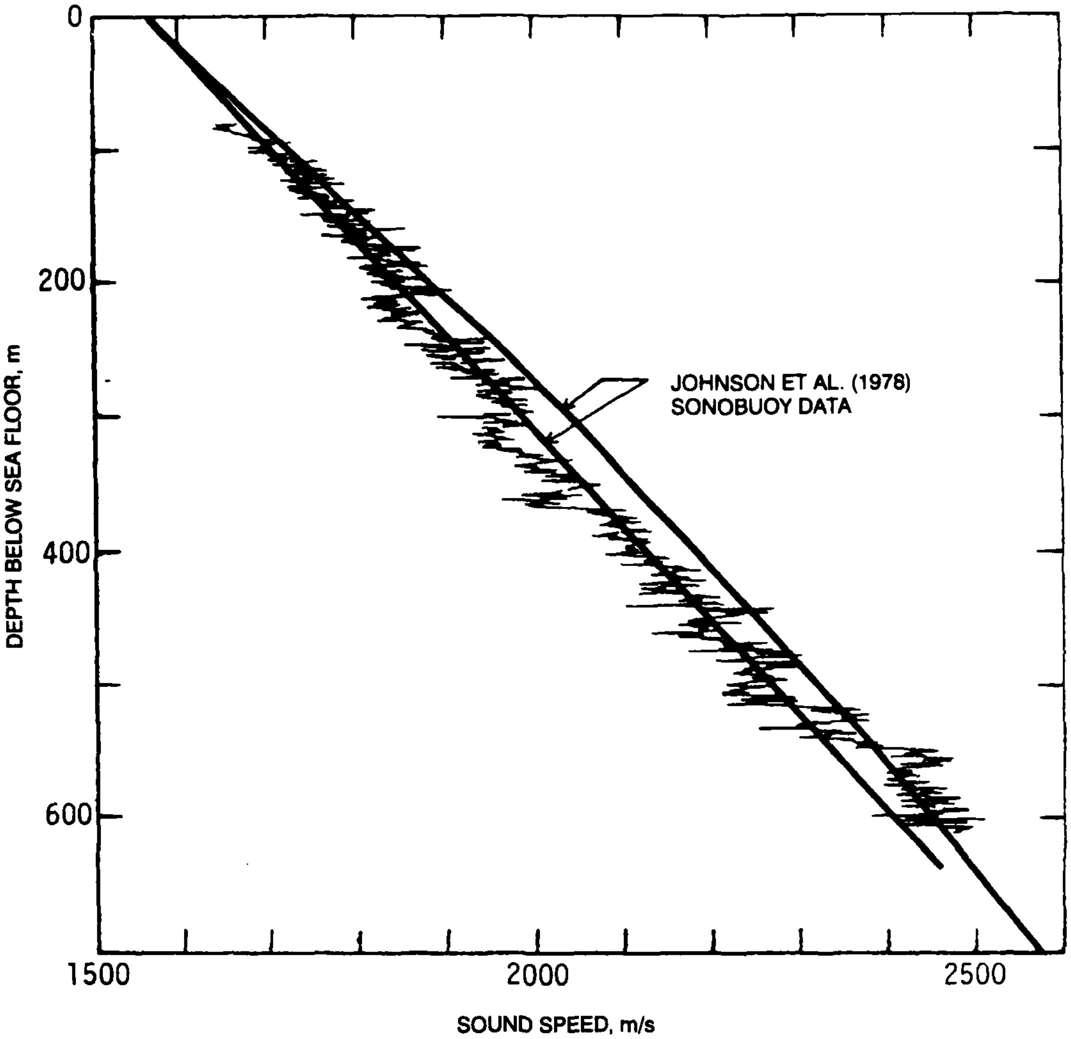


Figure A-1. In situ and seismic measurements of sound speed. Down-hole logging results from the Ontong Java Plateau compared with the seismic measurements of Bachman and Hamilton (Johnson et al., 1978). From Fulthorpe et al., 1989, figure 6.

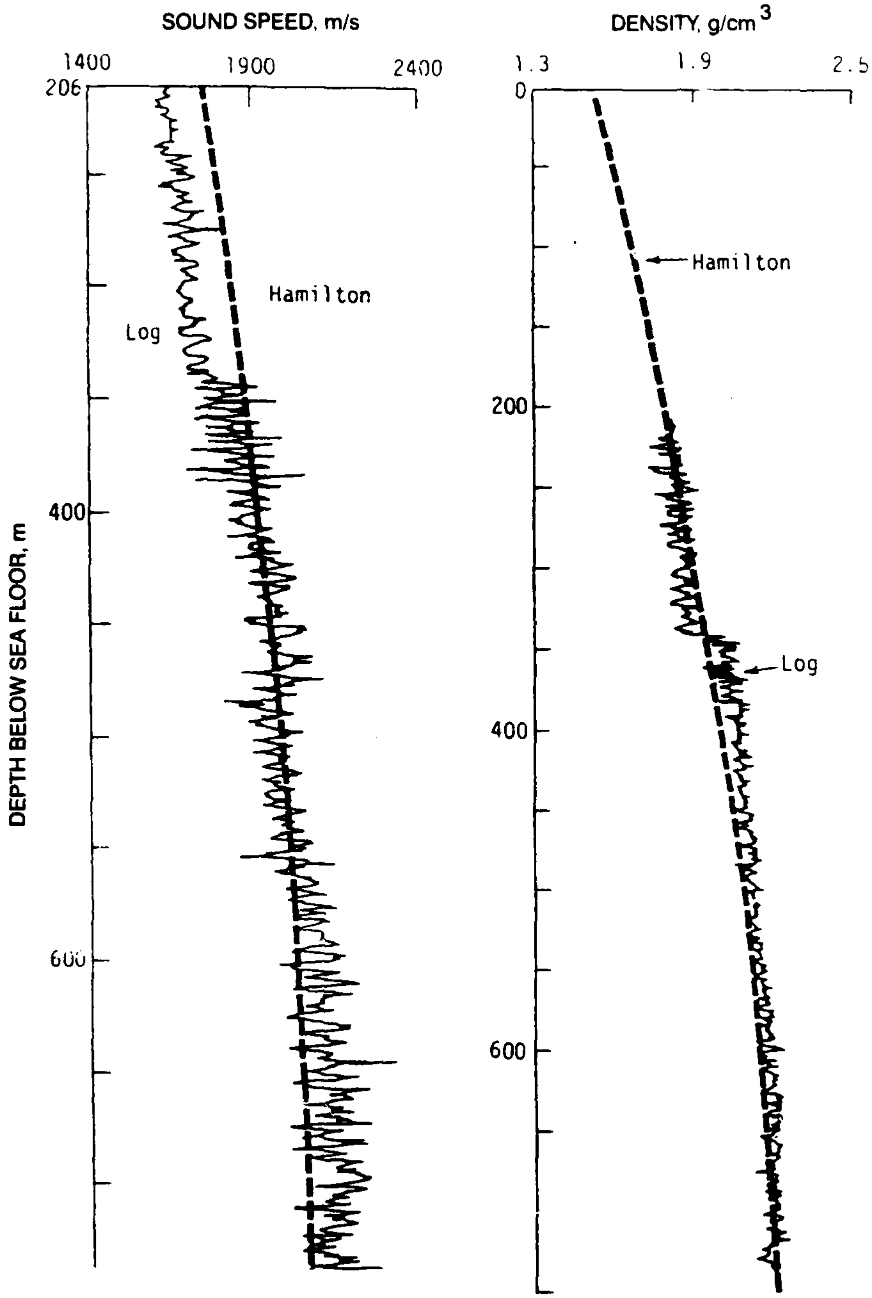


Figure A-2. In situ measurements of sound speed and density compared with predictions. Down-hole logging results from the Labrador Sea compared with Hamilton's average relationships for sound speed (1979a) and density (1976) in the same sediment type. From Jarrard et al., 1989, figures 1 and 12. Logging began at 206 m sub-bottom. Note different depth scales.

## COMPRESSIONAL WAVE ATTENUATION

Attenuation is expressed in terms of dB/m/kHz which, when multiplied by the frequency of sound in kHz, gives attenuation in dB/m of path length. This assumes that attenuation varies roughly linearly with frequency. More precisely, the assumption is that log attenuation (dB/m),

when plotted against log frequency, results in a line with a slope of approximately 1 (i.e., attenuation in dB/m = $kf^n$, where k has units of dB/m/kHz, f is frequency in kHz, and n is approximately 1). This relationship has been used to extrapolate attenuation measurements made at high frequencies to the lower frequencies of interest in oceanic sound propagation. The assumption that n is close enough to unity to ignore the difference has been misconstrued as a claim that n is identically 1 (e.g., Kibblewhite, 1989) and has thus been criticized on theoretical grounds (e.g., Stoll, 1980, 1985). Recently, Kibblewhite (1989) tried to reconcile measurements with theory.

Figure A-3 is a compilation from Kibblewhite (1989, figure 8) for silts and clays. On the basis of this figure and other considerations discussed in the text, Kibblewhite makes a case for an $f^1$ attenuation-frequency relationship above about 10 kHz and below about 1 kHz (p. 729); between these frequency regimes a nonlinear region is postulated. However, a line through the middle of the "silts and clays" region with a slope of 1 passes through the mid-frequency data cluster. An eye-fitted line has a slope of 1.2 over the range 1 to 10,000 Hz. Therefore, the details of the variation of attenuation with frequency is ignored, and an approximate $f^1$ relationship is used in this report.

The attenuation-depth curves of Mitchell and Focke (1980, figure 11) were used to establish a mean attenuation profile. Kibblewhite (1989, p. 720-721) criticizes these measurements because an $f^1$ dependence was assumed in the data reduction. However, Kibblewhite includes them in his figure 8, and they fall within his mid-frequency cluster of data. Because the values are reasonable when compared with other data, because they are based on in situ seismic measurements, and because they include depth dependence, the results of Mitchell and Focke are used in this report. In situ seismic measurements are especially useful because they include all energy loss mechanisms: intrinsic attenuation, scattering, multiple reflection, shear-conversion, etc.

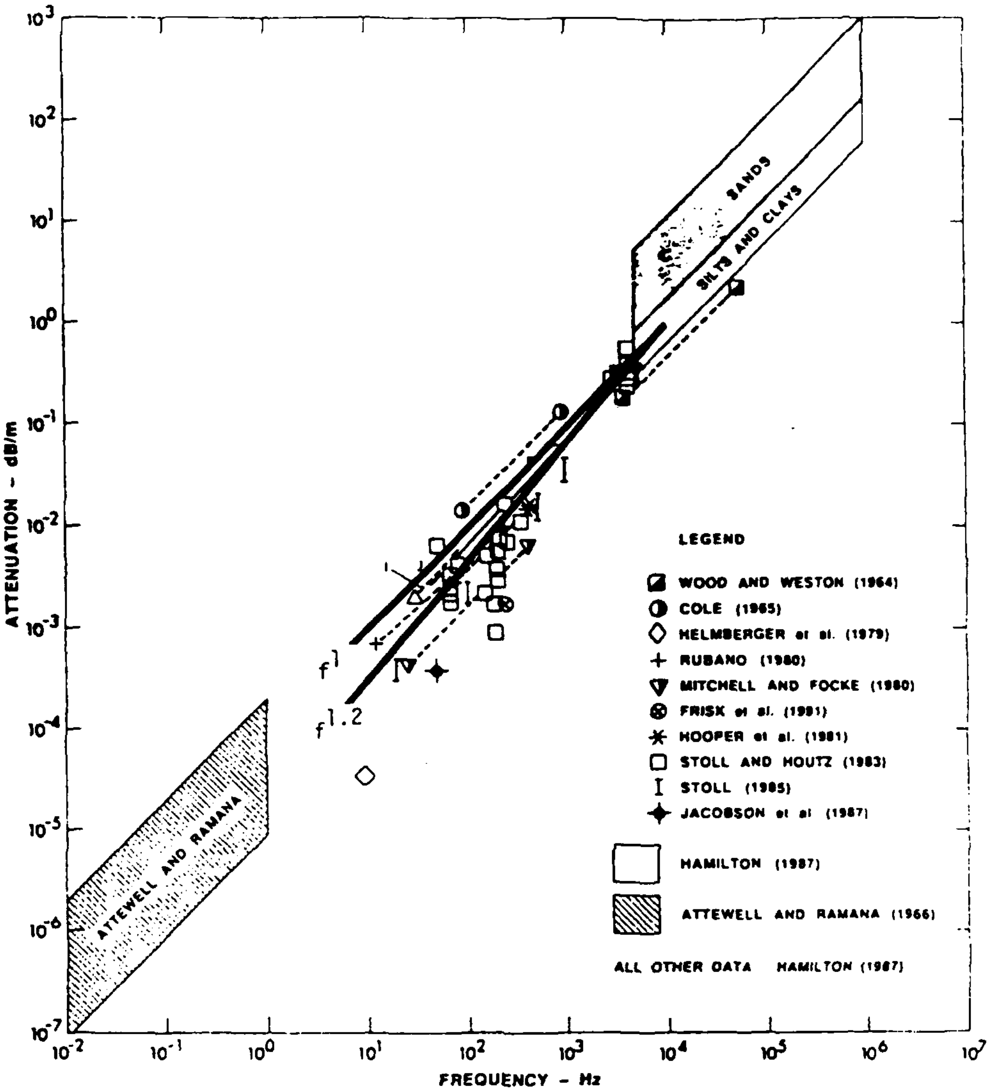


Figure A-3. Compilation of sound attenuation versus frequency measurements. Compressional wave attenuation measurements in silt-clay sediment and sedimentary rock compiled by Kibblewhite (1989, figure 8). The few mid-frequency measurements available suggest to Kibblewhite that the relationship between frequency and attenuation is nonlinear, as required by theory. To a first approximation, however, a line with a slope of 1 provides a reasonable fit to the existing data.

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# APPENDIX B: GRIDDED DATABASE

The geographic database is contained on the accompanying disk in the file CATLNADB.010. Each 32-character record pertains to a grid cell, which is a rectangular area of side-length equal to 15 seconds of latitude and longitude. Except along the periphery of the database area, each grid cell includes its eastern and southern borders and excludes its northern and western borders. Cells along the northern periphery include their northern border, and cells along the western periphery include their western border. This is illustrated in figure B-1. The first record of the file is for the northwest corner of the area, and the last record is for the southeast corner. In between, the records progress from west to east while latitude is held constant, then latitude is decremented, and the records progress from west to east again. The data format is shown in table B-1.

Given the row and column indices of a grid cell, latitude (center of grid cell, degrees) = $33.58541667 - \text{row\_index} * 4.16667\text{e}{-3}$, and longitude (center of grid cell, degrees) = $119.00208333 - \text{col\_index} * 4.16667\text{e}{-3}$. Given latitude and longitude in decimal degrees (positive north and west), $\text{row\_index} = 180 - \text{INT}((\text{latitude} - 32.833333) * 240)$, and $\text{col\_index} = 240 - \text{INT}((\text{longitude} - 118.) * 240)$.

The data file does not contain records for grid cells for which depth is not available.

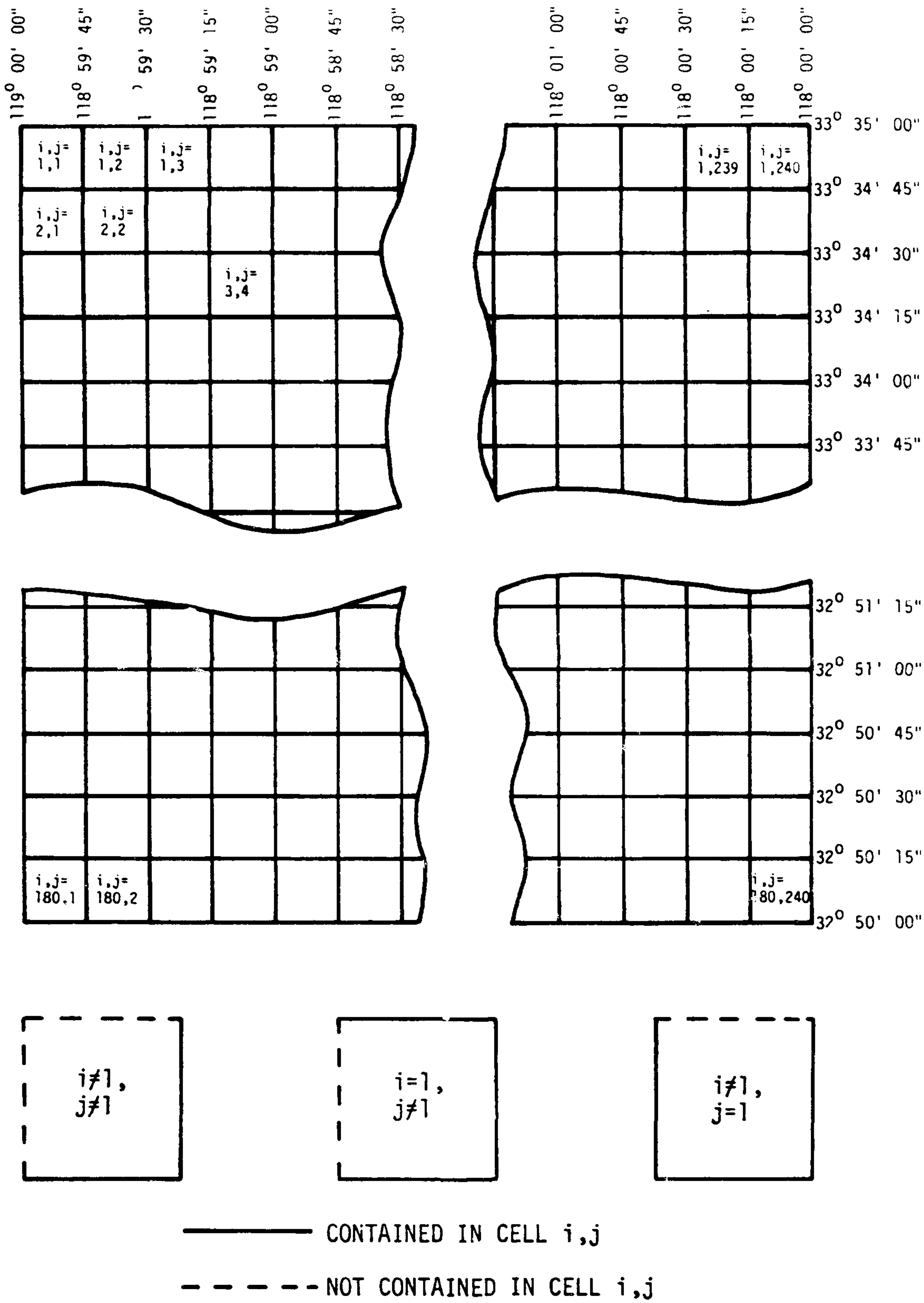


Figure B-1. Organization of the gridded database.

Table B-1. Geographic database file format.

| Columns | Format | Permissable Values | Comments | |
|---|---|---|---|---|
| 1 – 3 | I3 | 1 – 180 | Row index of grid cell | |
| 4 – 6 | I3 | 1 – 240 | Column index of grid cells | |
| 7 – 10 | I4 | –999<br>0 – 9999 | True water depth, m. –999 indicates land. | |
| 11 – 13 | F3.2 | 0.00 – 1.00 | Layer P2 thickness, 2-way s | (1) |
| 14 – 16 | F3.2 | 0.00 – 1.00 | Layer P1 thickness, 2-way s | (1) |
| 17 – 19 | F3.2 | 0.00 – 1.00 | P2 + P1 thickness, 2-way s | (1) |
| 20 – 22 | A3 | | Basement rock | |
| | | Tmp | Miocene plutonic & hypabyssal | |
| | | Tmu | Miocene volcanic & sedimentary (undifferentiated) | |
| | | Tm | Miocene sedimentary | |
| | | Tmv | Miocene volcanic | |
| | | Tpr | Late Miocene – Early Pliocene sedimentary (undifferentiated) | |
| | | Mz | Pre–Late Cretaceous metamorphic | |
| 23 – 25 | A3 | see basement rock above | Sea floor rock | |
| 26 – 29 | A4 | | Sea floor sediment name | |
| | | csnd | coarse sand | |
| | | sand | sand | |
| | | fsnd | fine sand | |
| | | mud | mud (assumed to be silt) | |
| 30 – 32 | F3.2 | | Mean grain size, phi units | |

**NOTE:** (1) Teng, 1985 (see appendix C).

# APPENDIX C: SEDIMENT THICKNESS

Sediment thickness was obtained from Teng (1985, figures 31 and 32). Teng subdivides the soft sediment column into two units, which he refers to as "P2" (the upper unit) and "P1." He postulates an unconformity (a period of nondeposition) between the two units, and if that is the case, there should be a discontinuity (probably slight) in the sediment property profiles at that point. No information is available with which to quantify such a discontinuity, and the possibility was ignored. Figure C-1 is a composite, summing the thicknesses of P1 and P2. The thickness data were gridded by assigning a uniform thickness to the region between contours equal to the average of those contours. For instance, the region between 0.2 and 0.3 s was assigned a uniform thickness of 0.25 s. Greene and Kennedy (1986) point out that ridges and ridge flanks, rather than being barren, are apt to have up to several meters of sediment cover.

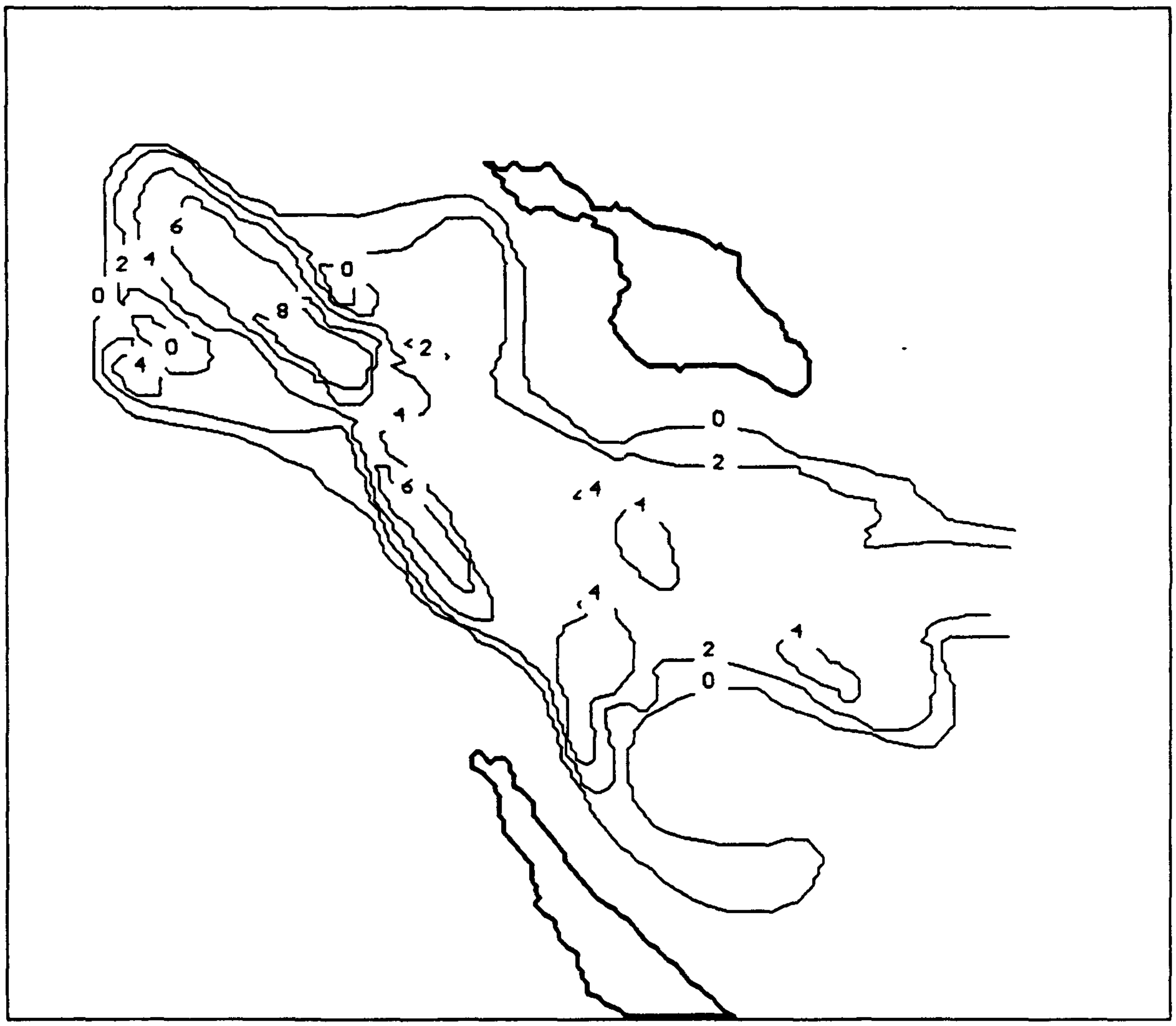


Figure C-1. Sediment thickness in the Catalina Basin (from Teng, 1985, figures 31 and 32). Contours are in tenths of seconds of two-way sound travel time. Areas mapped as devoid of sediment may have thicknesses up to 3 m according to Greene and Kennedy, 1986).

# REFERENCES (APPENDIX C)

Greene, H.G., and M.P. Kennedy, 1986, Geology of the Mid-Southern California Continental Margin; California Continental Margin Map Series, California Department of Mines and Geology.

Teng, L.S-Y., 1985, Seismic Stratigraphic Study of the California Continental Borderland Basins: Structure, Stratigraphy, and Sedimentation; Unpubl. Ph.D. thesis, Univ. Southern California.

# APPENDIX D: WATER DEPTH

Gridded bathymetric data for the area were obtained from the National Geophysical Data Center (NGDC; NGDC data announcement 87-MGG-12). These data were collected by the National Ocean Service (NOS) and predecessor organizations and are the basic data NOS uses to chart U.S. coastal waters. The data are gridded at a spacing of 15 seconds of latitude and longitude. Depths are referred to mean lower low water.

The gridding process used by NOS consisted of averaging all soundings occurring within a grid square and assigning the mean as the depth at the center of the square. If no soundings for a square were available, no depth was assigned (i.e., interpolation was not used). Figure D-1 illustrates the depth grid for the area as obtained from NGDC; whitespace indicates land or grid points lacking a depth.

As a quality-check, east-west profiles were plotted and compared with NOS bathymetric charts NI 11-7 and NI 11-10. On the basis of these comparisons, eight data points were identified as suspect and were not incorporated into the database.

Planar interpolation was then used to fill those empty grid squares of figure D-1 that are within Catalina Basin or on the San Clemente and Catalina Island ridges. For isolated empty squares and isolated clusters of a few empty squares, roughly equilateral triangles with data points as vertices and centered on the empty square were used. When a relatively large area lacked depth values, Delauney triangles were constructed and used for interpolations. These triangularize the data points in such a way that any measurement shares vertices with each of its immediate neighbors, any two adjacent measurements are linked by an edge, and all triangles are as equilateral as possible (see Watson, 1983, 1985, 1988; Watson and Philip, 1987). Interpolation was applied recursively, so that a given interpolation may be based on prior interpolations.

The resulting data set (illustrated in figures D-2 and D-3), was checked by again plotting east-west profiles to compare the interpolations with the original NOS data. No anomalies were noted. And finally, the data were computer-contoured and compared with a SeaBeam survey of Emery Knoll. The results are shown in figures D-4 and D-5. The SeaBeam survey was conducted by J.M. Stevenson (NRaD, Code 541, 30 September 1992), who also performed the contouring. In figure D-4 (SeaBeam data), peripheral contours should be ignored because the survey did not obtain sufficient data in these areas for reliable contouring. The interpolated NOS data agree quite well with the SeaBeam data for Emery Knoll proper.

Figure D-1. Gridded National Ocean Service depth data. Whitespace indicates land or grid locations that lack depths.

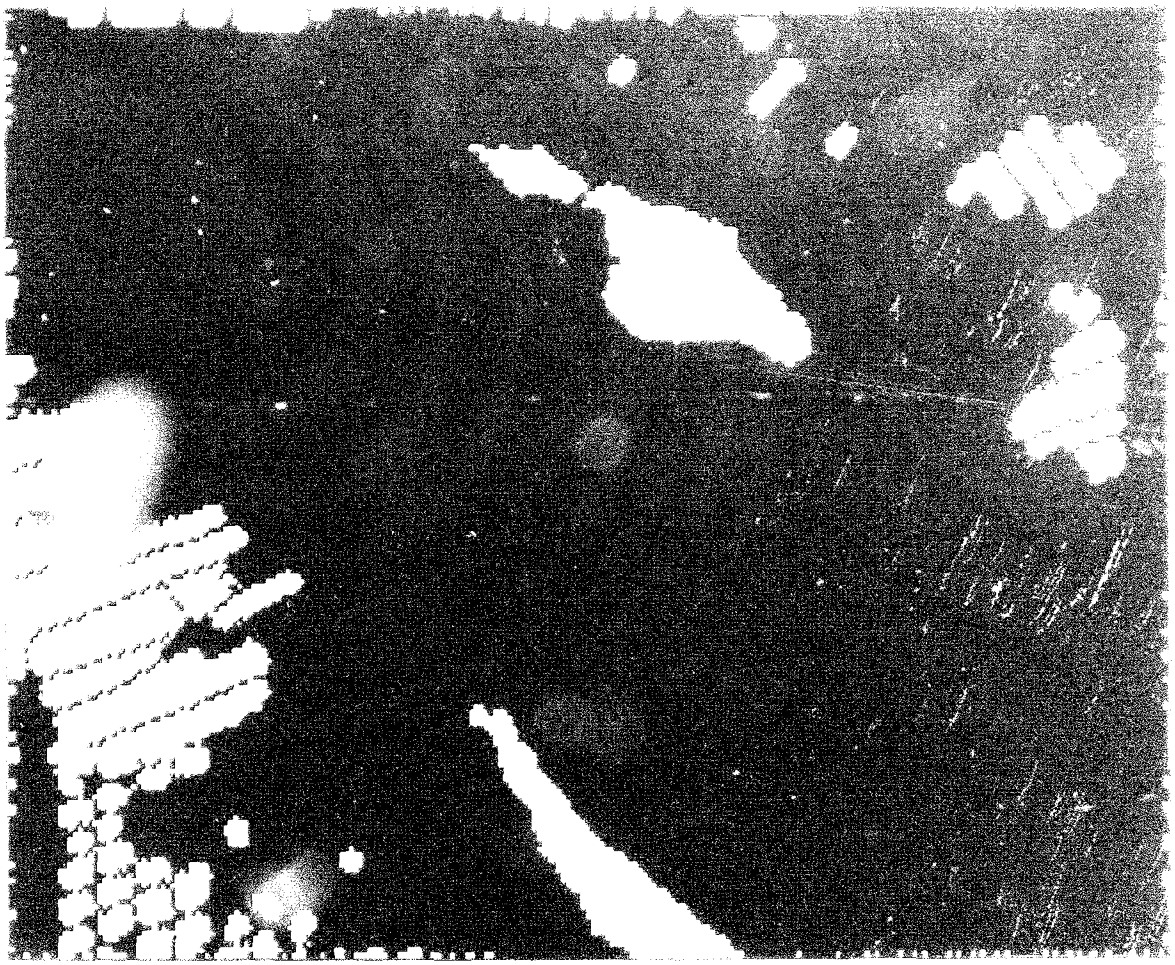

Figure D-2. Gridded National Ocean Service depth data and interpolations. Whitespace indicates land or grid locations that lack depths.

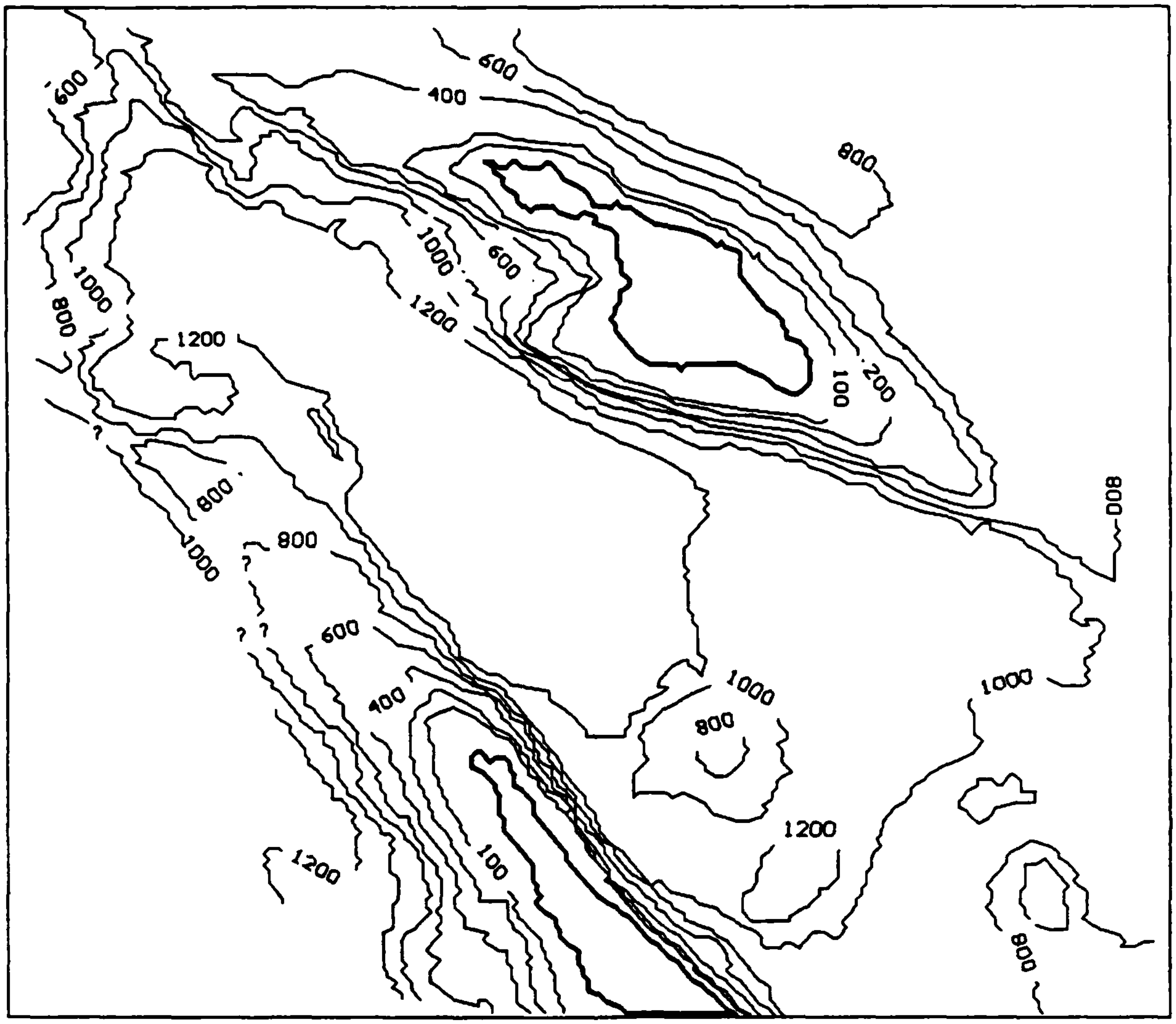


Figure D-3. Bathymetry of Catalina Basin constructed from final gridded bathymetry.

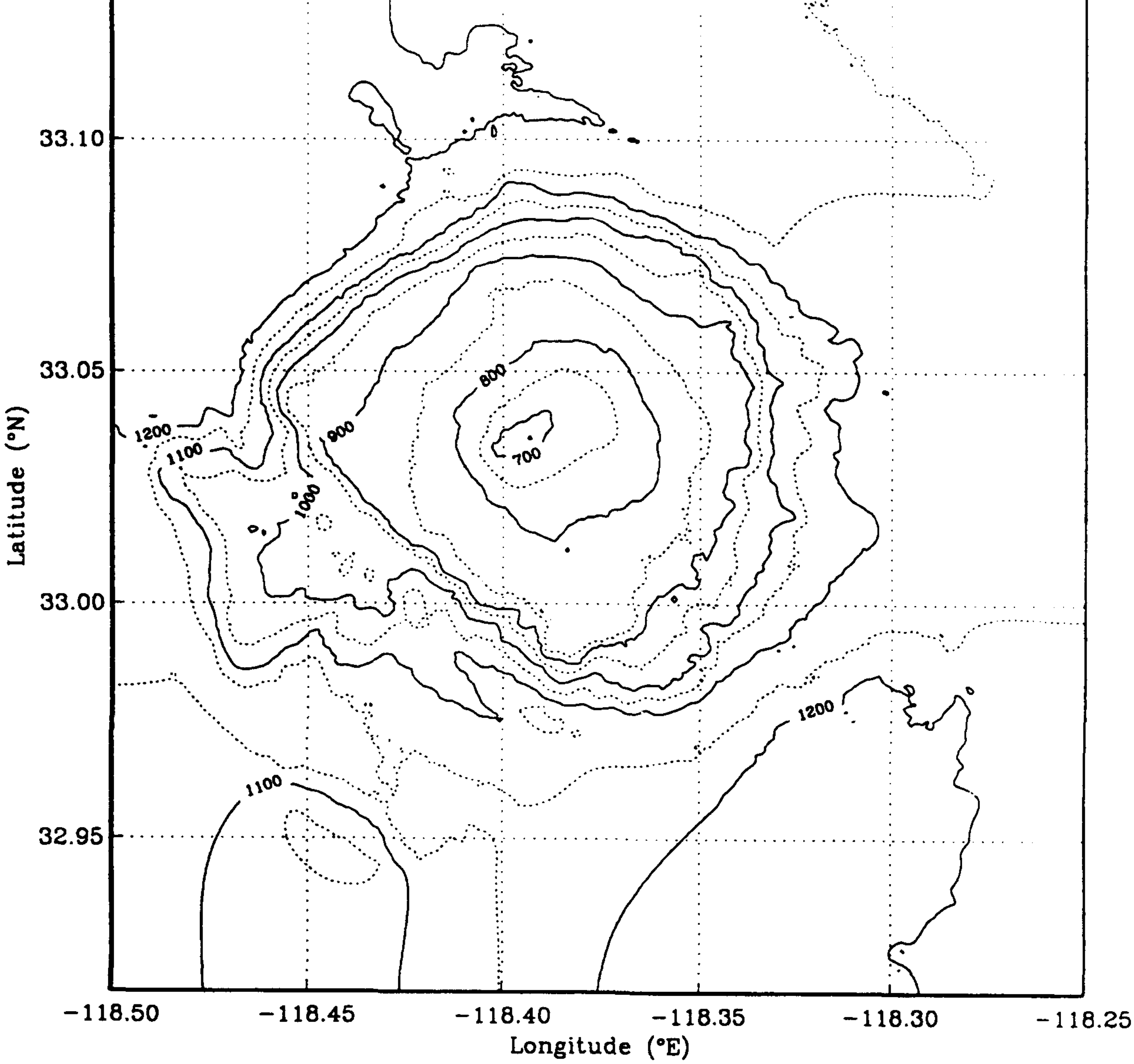


Figure D-4. SeaBeam survey of Emery Knoll. The soundings were gridded at a spacing of 100 m and computer-contoured. The survey concentrated on Emery Knoll, and contours away from the knoll are unreliable. The soundings assume a seawater sound speed of 1500 m/s.

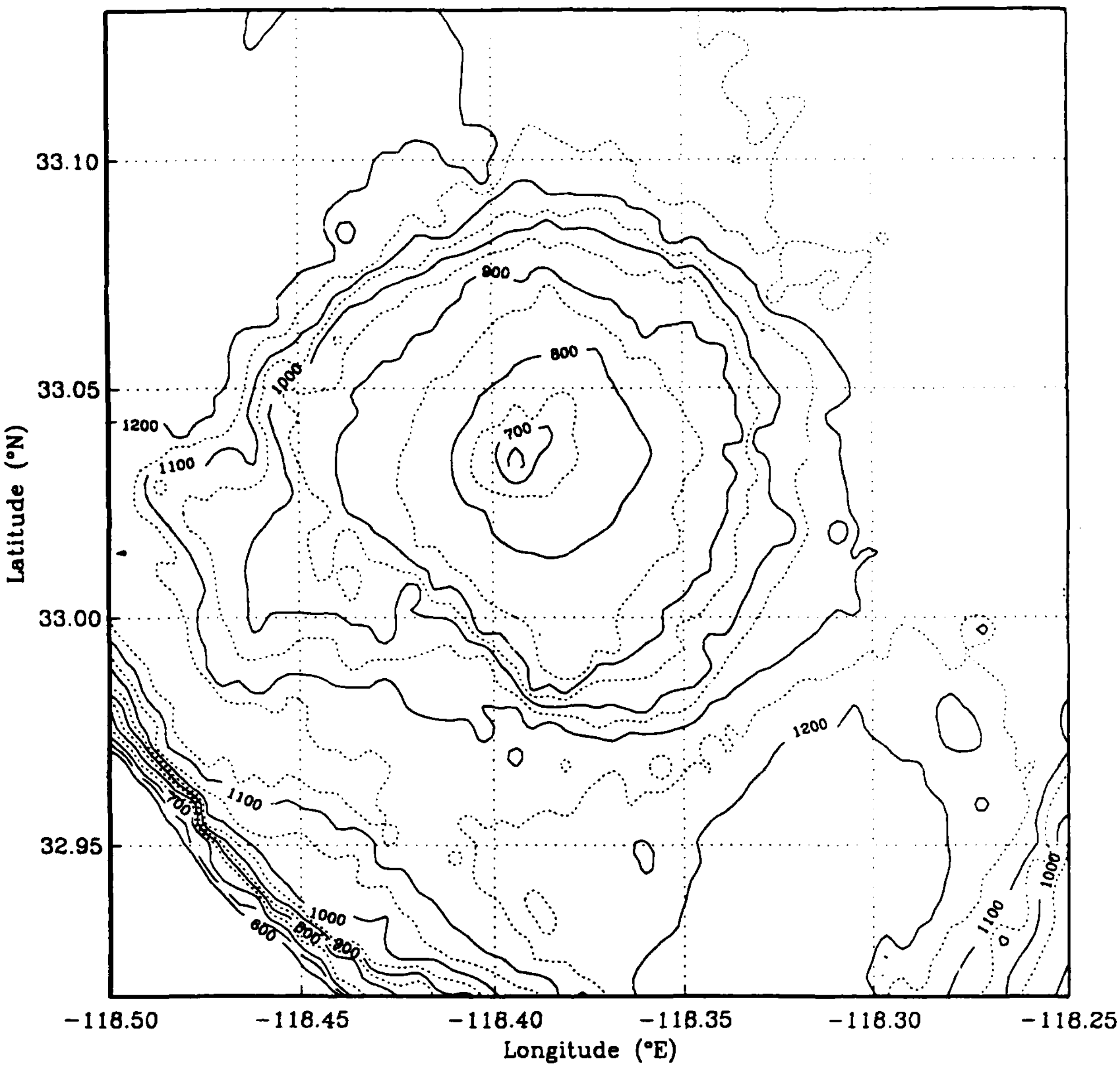


Figure D-5. Bathymetry of Emery Knoll based on gridded depths. Contoured from NOS data and interpolations. Compare with figure D-4, but keep in mind that NOS depth data are corrected for sound speed in seawater.

## REFERENCES (APPENDIX D)


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Watson, D.F., 1985, Natural Neighbour Sorting; *Australian Computer Journal*; 17:189-193.

Watson, D.F., 1988, Natural Neighbor Sorting on the n-Dimensional Sphere; *Pattern Recognition*, 21:63-67.

Watson, D.F., and G.M. Philip, 1987, Neighborhood-Based Interpolation; *Geobyte*, 2:12-16.

# APPENDIX E: MEAN GRAIN SIZE

Mean grain size is a commonly available index property from which acoustic and other sediment parameters may be computed. In this study, it is used to compute sound speed ratio and density and as the criterion separating “fine” from “coarse” sediment for geoacoustic modeling. Mean grain size as used herein includes both mean and median (see Folk and Ward, 1957).

Literature values of surface sediment mean grain size (appendix F) were assembled and used to generate Delauney triangles. This triangulation (see appendix D) was in turn used to interpolate for mean grain size in grid cells lacking measurements. Interpolations in the vicinity of Catalina Island were considered tenuous, so the surface geology of Welday and Williams (1975) was used as a guide to mean size as follows.

| SEDIMENT NAME | MEAN SIZE, PHI UNITS |
|---|---|
| Coarse sand | 0.5 |
| Sand | 1.5 |
| Fine sand | 3.0 |
| Mud | 5.4 |

Figure E-1 is the resulting contour map of mean grain size.

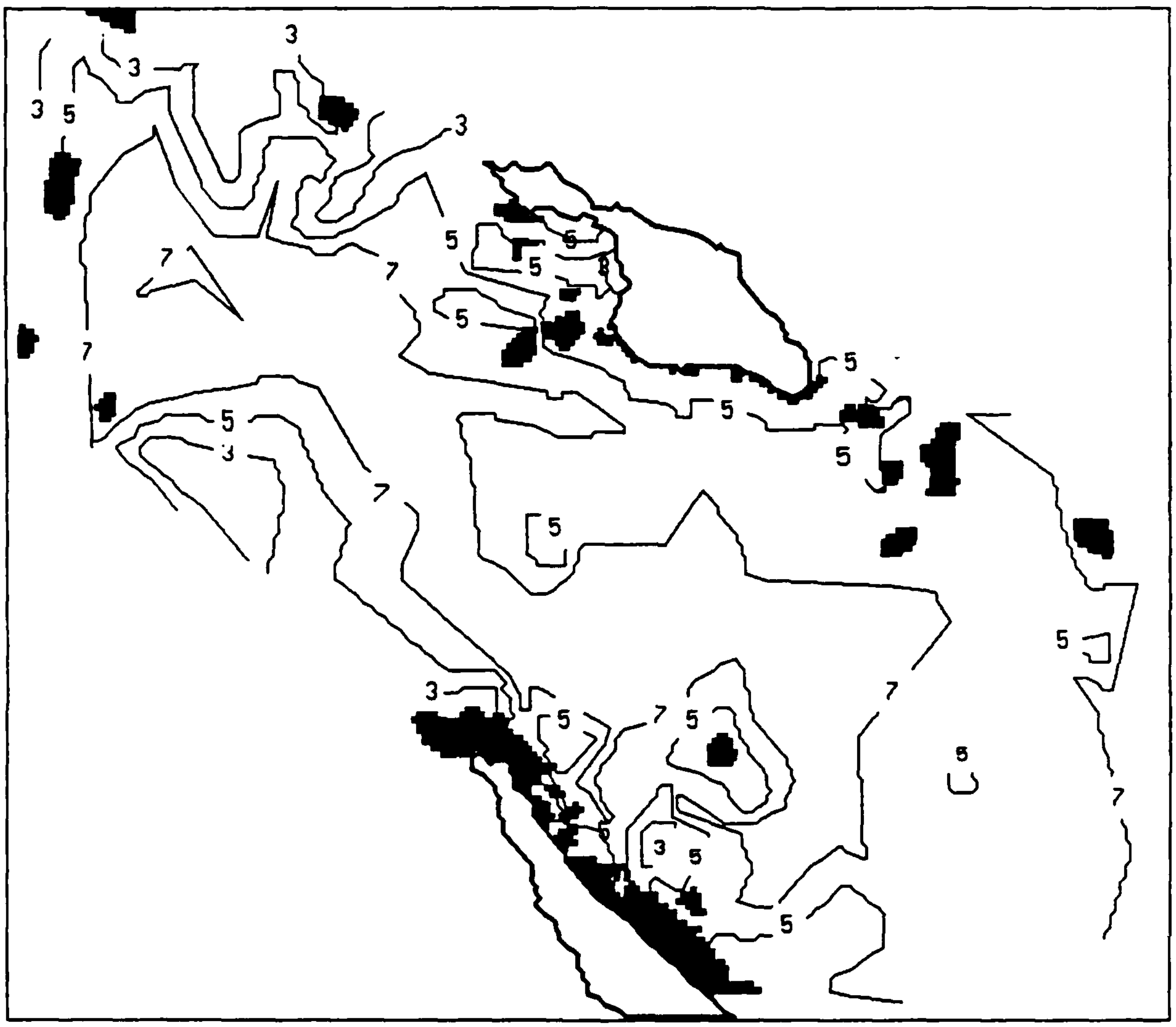


Figure E-1. Mean grain size contours in phi units. Black areas are rock outcrops.

# REFERENCES (APPENDIX E)

Folk, R.L., and W.C. Ward, 1957, Brazos River Bar: A Study of the Significance of Grain-Size Parameters; J. Sediment. *Petrology*, 27:3-26.

Welday, E.E., and J.W. Williams, 1975, Offshore Surficial Geology of California; California Div. Mines and Geology Map Sheet 26.

# APPENDIX F: SEDIMENT AND ROCK SAMPLES

Literature data on sediment and rock samples are assembled in tables F-1 (surface sediment samples) and F-2 (rock samples). Figures F-1 and F-2 show the sample locations.

The references below are keyed to the tables. Several of the references were obtained from the National Geophysical Data Center (NGDC). These are noted, along with the NGDC reference file number.

001 Vedder, J.G., L.A. Beyer, A. Junger, G.W. Moore, A.E. Roberts, J.C. Taylor, and H.C. Wagner, 1974, Preliminary Report on the Geology of the Continental Borderland of Southern California; U.S. Geological Survey Miscellaneous Field Studies Map MF-624 and accompanying report.

002 NGDC MGG file number 06055001.

003 Gaal, R A.P., 1966, Marine Geology of the Santa Catalina Basin Area, California; unpubl. Ph.D. thesis, Univ. of Southern California.

004 Bockman, P., D.S. Hill, and E. Achstetter, 1966, A Summary of Sediment Size, Composition, and Engineering Properties for PMR Project 121/02; September - October 1965; Naval Oceanographic Office, Geological Laboratory Branch Laboratory Item 277. NGDC MGG file number 09005011.

005 Ridlon, J.B., 1969, San Clemente Island Rocksite Project: Offshore Geology Part 2. Reconnaissance Survey Around the Island; Naval Undersea Research and Development Center Technical Paper NUC TP 156.

006 Emery, (K.O., ?), (date not provided), Submarine Canyons of Southern California; Alan Hancock Pacific Expeditions, v. 27, pt. 1. NGDC MGG file number 27025001.

007 Oser, R., J. Coleman, E. Achstetter, D. Hill, W. Johnson, C. Ross, J. Knoop, and V. Williams, 1967, A Summary of Engineering Properties, Sediment Size, and Composition Analyses of Cores from the Continental Borderland near San Clemente Island; October 1966 - December 1966. Deep Submergence System Project. U.S. Naval Oceanographic Office, Laboratory Branch Laboratory Item 303. NGDC MGG file number 09595003.

## Table F–1. Surface sediment samples.

| SAMPLE NO. | LATITUDE dd | LATITUDE mm.m | LONGITUDE ddd | LONGITUDE mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | CATALINA BASIN | | | | | | | |
| 2.0 | 33 | 22.5 | 118 | 47.5 | 003 | AHF 8315 | 1331 | 0 – 3 | ClSi | 7.89 | | | |
| 3.0 | 33 | 17.7 | 118 | 53.8 | 003 | AHF 8316 | 1333 | 0 – 3 | SiCl | 8.08 | | | |
| 4.0 | 33 | 14.2 | 118 | 37.5 | 003 | AHF 8317 | 1298 | 0 – 3 | SiCl | 7.96 | | | |
| 6.0 | 32 | 55.5 | 118 | 20.3 | 003 | AHF 8320 | 1260 | 0 – 3 | ClSi | 7.81 | | | |
| 7.0 | 33 | 7.5 | 118 | 9.0 | 003 | AHF 8321 | 1027 | 0 – 3 | ClSi | 6.30 | | | |
| 12.0 | 33 | 10.9 | 118 | 31.9 | 003 | AHF 8422 | 910 | 0 – 3 | SiSa | 4.04 | | | |
| 13.0 | 33 | 10.9 | 118 | 22.8 | 003 | AHF 8423 | 1184 | 0 – 3 | ClSi | 7.49 | | | |
| 14.0 | 33 | 19.3 | 118 | 43.0 | 003 | AHF 8424 | 1314 | 0 – 3 | SiCl | 7.72 | | | |
| 15.0 | 33 | 26.7 | 118 | 51.8 | 003 | AHF 8425 | 1243 | 0 – 3 | ClSi | 7.82 | | | |
| 18.0 | 33 | 13.3 | 118 | 12.3 | 003 | AHF 8686 | 1088 | 0 – 3 | SSC | 6.02 | | | |
| 19.0 | 33 | 9.5 | 118 | 14.6 | 003 | AHF 8687 | 1092 | 0 – 3 | ClSi | 7.00 | | | |
| 20.0 | 33 | 3.0 | 118 | 16.6 | 003 | AHF 8688 | 1109 | 0 – 3 | SiCl | 7.39 | | | |
| 23.0 | 32 | 58.7 | 118 | 26.4 | 003 | AHF 8691 | 1151 | 0 – 3 | Sa | 1.82 | | | |
| 24.0 | 33 | 5.9 | 118 | 24.5 | 003 | AHF 8692 | 1116 | 0 – 3 | ClSi | 7.71 | | | |
| 26.0 | 33 | 12.7 | 118 | 30.5 | 003 | NOTS–G–2 | 1371 | 0 – 3 | SSC | 6.32 | | | |
| 27.0 | 33 | 10.2 | 118 | 36.0 | 003 | NOTS–G–3 | 1463 | 0 – 3 | SiCl | 8.32 | | | |
| 28.0 | 33 | 14.2 | 118 | 19.2 | 003 | NOTS 4B | 1088 | 0 – 3 | SiSa | 5.09 | | | |
| 29.0 | 33 | 11.5 | 118 | 21.3 | 003 | NOTS 5 | 1153 | 0 – 3 | ClSi | 6.69 | | | |
| 30.0 | 33 | 5.5 | 118 | 27.5 | 003 | NOTS 6 | 1157 | 0 – 3 | ClSi | 7.14 | | | |
| 38.0 | 33 | 19.2 | 118 | 42.3 | 003 | NCEL 1 | 1317 | 0 – 3 | ClSi | 7.80 | | | |
| 39.0 | 33 | 15.2 | 118 | 39.0 | 003 | NCEL 2 | 1311 | 0 – 3 | SiCl | 8.13 | | | |
| 40.0 | 33 | 10.7 | 118 | 36.3 | 003 | NCEL 3 | 1297 | 0 – 3 | ClSi | 7.48 | | | |
| 41.0 | 32 | 56.2 | 118 | 20.0 | 003 | NCEL 4 | 1243 | 0 – 3 | ClSi | 7.83 | | | |
| 55.0 | 32 | 58.6 | 118 | 28.5 | 007 | DSSP 1 | 1134 | 0 – 15 | SSC | 6.88 | | | |
| 55.1 | 32 | 58.6 | 118 | 28.5 | 007 | DSSP 1 | 1134 | 15 – 30 | SiCl | 7.81 | | 1.31 | 79.8 |
| 56.0 | 32 | 56.7 | 118 | 20.1 | 007 | DSSP 2 | 1235 | 0 – 15 | ClSi | 7.72 | | | |
| 56.1 | 32 | 56.7 | 118 | 20.1 | 007 | DSSP 2 | 1235 | 15 – 22 | SiCl | 8.66 | | 1.26 | 83.0 |
| 56.2 | 32 | 56.7 | 118 | 20.1 | 007 | DSSP 2 | 1235 | 40 – 47 | SiCl | 8.35 | | 1.34 | 78.8 |
| 56.3 | 32 | 56.7 | 118 | 20.1 | 007 | DSSP 2 | 1235 | 65 – 72 | SiCl | 8.72 | | 1.33 | 79.4 |
| 56.4 | 32 | 56.7 | 118 | 20.1 | 007 | DSSP 2 | 1235 | 72 – 83 | SiCl | 8.34 | | | |
| 60.0 | 33 | 3.8 | 118 | 27.2 | 007 | DSSP 6 | 1097 | 0 – 15 | ClSi | 7.47 | | | |
| 60.1 | 33 | 3.8 | 118 | 27.2 | 007 | DSSP 6 | 1097 | 15 – 22 | Cl | 9.92 | | 1.30 | 80.7 |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | LATITUDE mm.m | LONGITUDE ddd | LONGITUDE mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CATALINA BASIN (continued) | | | | | | | | | | | | | |
| 60.2 | 33 | 3.8 | 118 | 27.2 | 007 | DSSP 6 | 1097 | 40 – 47 | Cl | 9.52 | | 1.37 | 77.0 |
| 60.3 | 33 | 3.8 | 118 | 27.2 | 007 | DSSP 6 | 1097 | 65 – 77 | Cl | 9.62 | | 1.37 | 77.0 |
| 61.0 | 33 | 7.7 | 118 | 33.6 | 007 | DSSP 7 | 1244 | 0 – 15 | ClSi | 7.73 | | | |
| 61.1 | 33 | 7.7 | 118 | 33.6 | 007 | DSSP 7 | 1244 | 15 – 22 | SiCl | 8.34 | | 1.27 | 82.2 |
| 61.2 | 33 | 7.7 | 118 | 33.6 | 007 | DSSP 7 | 1244 | 40 – 47 | SiCl | 8.74 | | 1.35 | 78.1 |
| 61.3 | 33 | 7.7 | 118 | 33.6 | 007 | DSSP 7 | 1244 | 65 – 76 | SiCl | 7.90 | | | |
| 62.0 | 33 | 3.2 | 118 | 28.3 | 007 | DSSP 10 | 1198 | 0 – 15 | ClSi | 7.08 | | | |
| 62.1 | 33 | 3.2 | 118 | 28.3 | 007 | DSSP 10 | 1198 | 40 – 47 | SiCl | 8.63 | | 1.34 | 78.9 |
| 62.2 | 33 | 3.2 | 118 | 28.3 | 007 | DSSP 10 | 1198 | 80 – 87 | SiCl | 8.06 | | 1.38 | 76.2 |
| 62.3 | 33 | 3.2 | 118 | 28.3 | 007 | DSSP 10 | 1198 | 100 – 112 | ClSi | 7.65 | | 1.46 | 71.9 |
| 66.0 | 33 | 9.7 | 118 | 30.7 | 007 | DSSP 14 | 1244 | 0 – 15 | SiCl | 8.33 | | | |
| 66.1 | 33 | 9.7 | 118 | 30.7 | 007 | DSSP 14 | 1244 | 15 – 22 | SiCl | 9.18 | | 1.29 | 81.7 |
| 66.2 | 33 | 9.7 | 118 | 30.7 | 007 | DSSP 14 | 1244 | 40 – 47 | SiCl | 8.73 | | 1.34 | 79.2 |
| 66.3 | 33 | 9.7 | 118 | 30.7 | 007 | DSSP 14 | 1244 | 65 – 77 | SiCl | 8.43 | | | |
| 67.0 | 33 | 8.2 | 118 | 33.1 | 007 | DSSP 15 | 1240 | 0 – 15 | SiCl | 8.29 | | | |
| 67.1 | 33 | 8.2 | 118 | 33.1 | 007 | DSSP 15 | 1240 | 15 – 22 | SiCl | 8.68 | | 1.29 | 81.8 |
| 67.2 | 33 | 8.2 | 118 | 33.1 | 007 | DSSP 15 | 1240 | 40 – 47 | SiCl | 8.90 | | 1.36 | 77.7 |
| 67.3 | 33 | 8.2 | 118 | 33.1 | 007 | DSSP 15 | 1240 | 80 – 90 | ClSi | 7.87 | | 1.62 | 63.5 |
| 70.0 | 33 | 6.5 | 118 | 26.6 | 007 | DSSP 19 | 1185 | 0 – 15 | ClSi | 7.87 | | | |
| 70.1 | 33 | 6.5 | 118 | 26.6 | 007 | DSSP 19 | 1185 | 15 – 22 | SiCl | 8.18 | | 1.29 | 80.7 |
| 70.2 | 33 | 6.5 | 118 | 26.6 | 007 | DSSP 19 | 1185 | 22 – 48 | SiCl | 8.12 | | | |
| 71.0 | 33 | 7.1 | 118 | 22.2 | 007 | DSSP 20 | 1158 | 0 – 15 | ClSi | 7.49 | | | |
| 71.1 | 33 | 7.1 | 118 | 22.2 | 007 | DSSP 20 | 1158 | 15 – 22 | SiCl | 8.99 | | 1.31 | 80.9 |
| 71.2 | 33 | 7.1 | 118 | 22.2 | 007 | DSSP 20 | 1158 | 40 – 47 | SiCl | 8.22 | | 1.46 | 72.2 |
| 71.3 | 33 | 7.1 | 118 | 22.2 | 007 | DSSP 20 | 1158 | 47 – 65 | SSC | 7.16 | | | |
| 72.0 | 33 | 5.5 | 118 | 25.1 | 007 | DSSP 21 | 1130 | 0 – 15 | SiCl | 7.90 | | | |
| 72.1 | 33 | 5.5 | 118 | 25.1 | 007 | DSSP 21 | 1130 | 15 – 22 | SiCl | 8.75 | | 1.32 | 80.7 |
| 72.2 | 33 | 5.5 | 118 | 25.1 | 007 | DSSP 21 | 1130 | 40 – 47 | SiCl | 8.83 | | 1.33 | 78.9 |
| 72.3 | 33 | 5.5 | 118 | 25.1 | 007 | DSSP 21 | 1130 | 80 – 87 | SiCl | 8.59 | | 1.40 | 75.3 |
| 72.4 | 33 | 5.5 | 118 | 25.1 | 007 | DSSP 21 | 1130 | 87 – 104 | ClSi | 7.16 | | | |
| 75.0 | 33 | 4.0 | 118 | 18.7 | 007 | DSSP 24 | 1134 | 0 – 15 | ClSi | 7.08 | | | |
| 75.1 | 33 | 4.0 | 118 | 18.7 | 007 | DSSP 24 | 1134 | 15 – 27 | ClSi | 7.66 | | 1.50 | 69.0 |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | LATITUDE mm.m | LONGITUDE ddd | LONGITUDE mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | CATALINA BASIN (continued) | | | | | | | |
| 77.0 | 32 | 57.8 | 118 | 18.3 | 007 | DSSP 26 | 1203 | 0 – 15 | SiCl | 8.04 | | | |
| 77.1 | 32 | 57.8 | 118 | 18.3 | 007 | DSSP 26 | 1203 | 15 – 22 | | 5.15 | | 1.31 | 79.7 |
| 77.2 | 32 | 57.8 | 118 | 18.3 | 007 | DSSP 26 | 1203 | 40 – 47 | SiCl | 8.88 | | 1.37 | 77.0 |
| 83.0 | 32 | 54.9 | 118 | 22.2 | 007 | DSSP 35 | 1134 | 15 – 22 | ClSi | 7.61 | | 1.40 | 76.1 |
| 83.1 | 32 | 54.9 | 118 | 22.2 | 007 | DSSP 35 | 1134 | 40 – 47 | SiCl | 7.99 | | 1.41 | 74.6 |
| 83.2 | 32 | 54.9 | 118 | 22.2 | 007 | DSSP 35 | 1134 | 80 – 87 | SiCl | 7.21 | | 1.49 | 70.0 |
| 83.3 | 32 | 54.9 | 118 | 22.2 | 007 | DSSP 35 | 1134 | 100 – 117 | SSC | 6.09 | | | |
| | | | | | | CATALINA RIDGE/ISLAND SLOPE | | | | | | | |
| 1.0 | 33 | 22.8 | 118 | 38.5 | 003 | AHF 8314 | 105 | 0 – 3 | ClSi | 5.90 | | | |
| 16.0 | 33 | 26.4 | 118 | 40.0 | 003 | AHF 8426 | 728 | 0 – 3 | SSC | 5.91 | | | |
| 25.0 | 33 | 15.5 | 118 | 24.6 | 003 | NOTS–G–1 | 1689 | 0 – 3 | SSC | 6.74 | | | |
| 36.0 | 33 | 10.3 | 118 | 1.1 | 003 | NOTS 18 | 919 | 0 – 3 | ClSi | | 7.38 | | |
| 45.0 | 33 | 22.9 | 118 | 31.0 | 006 | 6818 | 362 | | Si | | 5.16 | | |
| 46.0 | 33 | 22.9 | 118 | 31.1 | 006 | 6819 | 379 | | Si | | 5.01 | | |
| 47.0 | 33 | 23.2 | 118 | 32.2 | 006 | 6820 | 559 | | SaSi | | 4.64 | | |
| 48.0 | 33 | 23.2 | 118 | 30.0 | 006 | 6822 | 216 | | Si | | 5.11 | | |
| 49.0 | 33 | 23.2 | 118 | 29.6 | 006 | 6823 | 88 | | ClSi | | 5.80 | | |
| 50.0 | 33 | 23.2 | 118 | 30.0 | 006 | 6824 | 206 | | ClSi | | 6.65 | | |
| 51.0 | 33 | 23.2 | 118 | 31.3 | 006 | 6825 | 363 | | ClSi | | 5.01 | | |
| 52.0 | 33 | 20.3 | 118 | 38.8 | 006 | 6827 | 1245 | | ClSi | | 6.06 | | |
| 53.0 | 33 | 20.5 | 118 | 39.1 | 006 | 6828 | 1272 | | ClSi | | 7.15 | | |
| 54.0 | 33 | 24.0 | 118 | 34.4 | 006 | 6831 | 549 | | ClSi | | 5.72 | | |
| | | | | | | SAN CLEMENTE RIDGE/ISLAND SLOPE | | | | | | | |
| 5.0 | 33 | 5.6 | 118 | 34.2 | 003 | AHF 8319 | 1228 | 0 – 3 | ClSi | 7.61 | | | |
| 11.0 | 33 | 2.2 | 118 | 31.7 | 003 | AHF 8421 | 530 | 0 – 3 | SiSa | 2.33 | | | |
| 22.0 | 32 | 51.7 | 118 | 22.0 | 003 | AHF 8690 | 782 | 0 – 3 | SSC | 6.26 | | | |
| 31.0 | 33 | 2.4 | 118 | 32.9 | 003 | NOTS 7 | 505 | 0 – 3 | ClSi | 7.02 | | | |
| 32.0 | 32 | 57.7 | 118 | 28.4 | 003 | NOTS 8 | 1101 | 0 – 3 | ClSi | 6.16 | | | |
| 33.0 | 32 | 51.0 | 118 | 20.3 | 003 | NOTS 9 | 758 | 0 – 3 | SiSa | 4.47 | | | |
| 43.0 | 33 | 15.3 | 118 | 56.1 | 004 | PMR122 BS–5 | 604 | 0 – 9 | SSC | 7.23 | | | |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | LATITUDE mm.m | LONGITUDE ddd | LONGITUDE mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAN CLEMENTE RIDGE/ISLAND SLOPE (continued) | | | | | | | | | | | | | |
| 44.0 | 33 | 9.9 | 118 | 47.1 | 004 | PMR122 BS–6 | 732 | 0 – 10 | Sa | 2.95 | | | |
| 68.0 | 33 | 6.4 | 118 | 35.6 | 007 | DSSP 16 | 1244 | 0 – 15 | ClSi | 7.05 | | | |
| 68.1 | 33 | 6.4 | 118 | 35.6 | 007 | DSSP 16 | 1244 | 15 – 22 | SiCl | 9.00 | | 1.30 | 79.6 |
| 68.2 | 33 | 6.4 | 118 | 35.6 | 007 | DSSP 16 | 1244 | 40 – 47 | SiCl | 8.45 | | 1.37 | 77.7 |
| 68.3 | 33 | 6.4 | 118 | 35.6 | 007 | DSSP 16 | 1244 | 80 – 96 | SiCl | 8.52 | | | |
| 69.0 | 33 | 5.5 | 118 | 33.5 | 007 | DSSP 18 | 1218 | 0 – 15 | ClSi | 7.66 | | | |
| 69.1 | 33 | 5.5 | 118 | 33.5 | 007 | DSSP 18 | 1218 | 15 – 22 | SiCl | 8.94 | | 1.28 | 81.8 |
| 69.2 | 33 | 5.5 | 118 | 33.5 | 007 | DSSP 18 | 1218 | 40 – 47 | SiCl | 8.70 | | 1.35 | 77.3 |
| 69.3 | 33 | 5.5 | 118 | 33.5 | 007 | DSSP 18 | 1218 | 65 – 86 | SiCl | 7.69 | | | |
| 59.2 | 33 | 0.7 | 118 | 25.7 | 007 | DSSP 5 | 960 | 40 – 47 | SSC | 5.16 | | 1.58 | 65.7 |
| 59.3 | 33 | 0.7 | 118 | 25.7 | 007 | DSSP 5 | 960 | 65 – 82 | SiSa | 3.39 | | | |
| 63.0 | 33 | 0.4 | 118 | 25.8 | 007 | DSSP 11 | 969 | 0 – 8 | SSC | 4.73 | | | |
| 64.0 | 32 | 59.7 | 118 | 25.4 | 007 | DSSP 12 | 1077 | 0 – 15 | SiCl | 7.83 | | | |
| 64.1 | 32 | 59.7 | 118 | 25.4 | 007 | DSSP 12 | 1077 | 40 – 47 | SiCl | 8.57 | | 1.40 | 74.7 |
| 64.2 | 32 | 59.7 | 118 | 25.4 | 007 | DSSP 12 | 1077 | 75 – 85 | SiCl | 8.15 | | | |
| 73.0 | 33 | 1.8 | 118 | 22.7 | 007 | DSSP 22 | 786 | 0 – 7 | SiSa | 3.41 | | | |
| 74.0 | 33 | 2.8 | 118 | 21.4 | 007 | DSSP 23 | 867 | 0 – 22 | SiSa | 4.08 | | 1.74 | 58.7 |
| 74.1 | 33 | 2.8 | 118 | 21.4 | 007 | DSSP 23 | 867 | 22 – 36 | SiSa | 4.63 | | | |
| 76.0 | 33 | 1.7 | 118 | 18.0 | 007 | DSSP 25 | 1097 | 0 – 15 | SiCl | 8.95 | | | |
| 76.1 | 33 | 1.7 | 118 | 18.0 | 007 | DSSP 25 | 1097 | 15 – 22 | SiCl | 8.32 | | 1.36 | 78.3 |
| 76.2 | 33 | 1.7 | 118 | 18.0 | 007 | DSSP 25 | 1097 | 22 – 37 | SiCl | 8.49 | | | |
| 84.0 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 0 – 7 | SSC | 5.96 | | 1.41 | 75.4 |
| EMERY KNOLL | | | | | | | | | | | | | |
| 8.0 | 33 | 4.0 | 118 | 21.2 | 003 | AHF 8418 | 1134 | 0 – 3 | SiCl | 8.06 | | | |
| 9.0 | 33 | 2.0 | 118 | 23.5 | 003 | AHF 8419 | 728 | 0 – 3 | Sa | 1.92 | | | |
| 10.0 | 33 | 2.2 | 118 | 23.8 | 003 | AHF 8420 | 785 | 0 – 3 | Sa | 2.19 | | | |
| 58.0 | 32 | 58.8 | 118 | 22.8 | 007 | DSSP 4 | 1015 | 0 – 15 | SSC | 7.13 | | | |
| 58.1 | 32 | 58.8 | 118 | 22.8 | 007 | DSSP 4 | 1015 | 15 – 22 | SiCl | 9.09 | | 1.36 | 78.3 |
| 58.2 | 32 | 58.8 | 118 | 22.8 | 007 | DSSP 4 | 1015 | 40 – 47 | SiCl | 9.17 | | 1.39 | 76.3 |
| 58.3 | 32 | 58.8 | 118 | 22.8 | 007 | DSSP 4 | 1015 | 47 – 65 | SiCl | 8.29 | | | |
| 59.0 | 33 | 0.7 | 118 | 25.7 | 007 | DSSP 5 | 960 | 0 – 15 | SSC | 6.63 | | | |
| 59.1 | 33 | 0.7 | 118 | 25.7 | 007 | DSSP 5 | 960 | 15 – 22 | ClSi | 7.26 | | 1.39 | 76.6 |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | mm.m | LONGITUDE ddd | mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | EMERY KNOLL (continued) | | | | | | | |
| 84.1 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 20 – 26 | SiCl | 7.60 | | 1.33 | 79.0 |
| 84.2 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 40 – 47 | SSC | 6.43 | | 1.49 | 70.5 |
| 84.3 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 60 – 66 | SSC | 6.09 | | 1.56 | 67.5 |
| 84.4 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 80 – 87 | SSC | 5.68 | | 1.61 | 63.9 |
| 84.5 | 32 | 58.5 | 118 | 23.0 | 007 | DSSP 42 | 995 | 95 – 101 | SSC | 5.19 | | 1.58 | 65.6 |
| 85.0 | 32 | 58.5 | 118 | 21.9 | 007 | DSSP 43 | 969 | 0 – 7 | SSC | 7.31 | | 1.43 | 74.5 |
| 85.1 | 32 | 58.5 | 118 | 21.9 | 007 | DSSP 43 | 969 | 8 – 20 | SiCl | 8.36 | | | |
| 85.2 | 32 | 58.5 | 118 | 21.9 | 007 | DSSP 43 | 969 | 20 – 25 | Cl | 9.47 | | 1.38 | 76.9 |
| 85.3 | 32 | 58.5 | 118 | 21.9 | 007 | DSSP 43 | 969 | 25 – 40 | SiCl | 8.64 | | | |
| 85.4 | 32 | 58.5 | 118 | 21.9 | 007 | DSSP 43 | 969 | 40 – 57 | SiCl | 8.31 | | 1.39 | 75.9 |
| 86.0 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 0 – 7 | SiCl | 7.77 | | 1.33 | 79.0 |
| 86.1 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 8 – 20 | SiCl | 8.78 | | | |
| 86.2 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 20 - 27 | SiCl | 8.99 | | 1.32 | 80.8 |
| 86.3 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 27 – 40 | SiCl | 7.56 | | | |
| 86.4 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 40 – 45 | SaCl | 7.34 | | 1.46 | 71.5 |
| 86.5 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 45 – 55 | SSC | 6.02 | | | |
| 86.6 | 32 | 59.2 | 118 | 20.5 | 007 | DSSP 44 | 951 | 55 – 69 | ClSa | 5.97 | | 1.58 | 65.6 |
| 87.0 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 0 – 7 | Sa | 3.69 | | 1.61 | 64.5 |
| 87.1 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 8 – 20 | ClSa | 4.21 | | | |
| 87.2 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 20 – 25 | ClSa | 4.49 | | 1.63 | 64.1 |
| 87.3 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 30 – 40 | Sa | 3.61 | | | |
| 87.4 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 40 – 50 | Sa | 3.69 | | 1.62 | 64.1 |
| 87.5 | 32 | 59.8 | 118 | 21.4 | 007 | DSSP 45 | 845 | 55 – 67 | Sa | 3.31 | | 1.68 | 54.8 |
| 88.0 | 33 | 1.8 | 118 | 23.3 | 007 | DSSP 47 | 695 | 0 – 3 | Sa | 3.64 | | | |
| 89.0 | 33 | 1.7 | 118 | 26.0 | 007 | DSSP 48 | 878 | 0 – 7 | ClSa | 5.23 | | 1.49 | 71.6 |
| 90.0 | 33 | 4.1 | 118 | 25.8 | 007 | DSSP 49 | 988 | 0 – 8 | SaCl | 7.72 | | 1.38 | 76.8 |
| 90.1 | 33 | 4.1 | 118 | 25.8 | 007 | DSSP 49 | 988 | 8 – 20 | SiCl | 8.66 | | | |
| 90.2 | 33 | 4.1 | 118 | 25.8 | 007 | DSSP 49 | 988 | 20 – 26 | SiCl | 8.71 | | 1.42 | 74.9 |
| 90.3 | 33 | 4.1 | 118 | 25.8 | 007 | DSSP 49 | 988 | 27 – 40 | SaCl | 6.57 | | | |
| 90.4 | 33 | 4.1 | 118 | 25.8 | 007 | DSSP 49 | 988 | 40 – 51 | ClSa | 5.22 | | 1.65 | 61.3 |
| 91.0 | 33 | 3.8 | 118 | 22.9 | 007 | DSSP 50 | 825 | 0 – 7 | ClSa | 4.48 | | 1.59 | 65.3 |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | mm.m | LONGITUDE ddd | mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMERY KNOLL (continued) | | | | | | | | | | | | | |
| 91.3 | 33 | 3.8 | 118 | 22.9 | 007 | DSSP 50 | 825 | 27 – 40 | Sa | 3.38 | | | |
| 91.4 | 33 | 3.8 | 118 | 22.9 | 007 | DSSP 50 | 825 | 40 – 52 | SiSa | 2.19 | | 1.82 | 54.1 |
| 93.0 | 32 | 59.5 | 118 | 18.9 | 007 | DSSP 52 | 1064 | 0 – 15 | SiCl | 9.05 | | | |
| 93.1 | 32 | 59.5 | 118 | 18.9 | 007 | DSSP 52 | 1064 | 15 – 22 | SiCl | 9.00 | | 1.32 | 79.8 |
| 93.2 | 32 | 59.5 | 118 | 18.9 | 007 | DSSP 52 | 1064 | 40 – 47 | SiCl | 8.37 | | 1.37 | 76.6 |
| 93.3 | 32 | 59.5 | 118 | 18.9 | 007 | DSSP 52 | 1064 | 65 – 72 | SiCl | 8.31 | | 1.40 | 74.9 |
| 93.4 | 32 | 59.5 | 118 | 18.9 | 007 | DSSP 52 | 1064 | 80 – 93 | SiCl | 8.47 | | | |
| 91.1 | 33 | 3.8 | 118 | 22.9 | 007 | DSSP 50 | 825 | 8 – 20 | Sa | 3.61 | | | |
| 91.2 | 33 | 3.8 | 118 | 22.9 | 007 | DSSP 50 | 825 | 20 – 26 | Sa | 3.24 | | 1.68 | 62.0 |
| MISCELLANEOUS | | | | | | | | | | | | | |
| 17.0 | 33 | 6.9 | 118 | 3.3 | 003 | AHF 8685 | 987 | 0 – 3 | SiSa | 4.24 | | | |
| 21.0 | 32 | 50.8 | 118 | 17.9 | 003 | AHF 8689 | 999 | 0 – 3 | SiSa | 3.97 | | | |
| 34.0 | 32 | 55.6 | 118 | 16.1 | 003 | NOTS 15 | 1046 | 0 – 3 | SSC | 4.26 | | | |
| 35.0 | 33 | 1.0 | 118 | 10.6 | 003 | NOTS 16 | 822 | 0 – 3 | SiSa | 4.79 | | | |
| 37.0 | 33 | 15.0 | 118 | 2.4 | 003 | NOTS 18A | 880 | 0 – 3 | ClSi | 7.53 | | | |
| 42.0 | 32 | 58.6 | 118 | 17.4 | 003 | NCEL 5 | 1259 | 0 – 3 | SiCl | 8.23 | | | |
| 57.0 | 32 | 58.5 | 118 | 17.0 | 007 | DSSP 3 | 1143 | 0 – 15 | ClSi | 7.60 | | | |
| 57.1 | 32 | 58.5 | 118 | 17.0 | 007 | DSSP 3 | 1143 | 15 – 22 | SiCl | 8.50 | | 1.30 | 79.7 |
| 57.2 | 32 | 58.5 | 118 | 17.0 | 007 | DSSP 3 | 1143 | 40 – 47 | SiCl | 8.41 | | 1.35 | 77.8 |
| 57.3 | 32 | 58.5 | 118 | 17.0 | 007 | DSSP 3 | 1143 | 65 – 75 | SiCl | 8.53 | | | |
| 65.0 | 32 | 53.8 | 118 | 15.5 | 007 | DSSP 13 | 850 | 0 – 15 | SiSa | 2.94 | | | |
| 78.0 | 32 | 56.3 | 118 | 14.2 | 007 | DSSP 27 | 841 | 0 – 15 | SSC | 6.57 | | | |
| 78.1 | 32 | 56.3 | 118 | 14.2 | 007 | DSSP 27 | 841 | 15 – 22 | SSC | 6.85 | | 1.42 | 73.7 |
| 78.2 | 32 | 56.3 | 118 | 14.2 | 007 | DSSP 27 | 841 | 40 – 47 | SSC | 5.59 | | 1.57 | 66.1 |
| 78.3 | 32 | 56.3 | 118 | 14.2 | 007 | DSSP 27 | 841 | 75 – 83 | SSC | 5.24 | | | |
| 79.0 | 32 | 55.5 | 118 | 15.4 | 007 | DSSP 28 | 905 | 0 – 10 | SSC | 5.30 | | | |
| 80.0 | 32 | 53.0 | 118 | 13.6 | 007 | DSSP 29 | 796 | 0 – 15 | ClSi | 6.91 | | | |
| 80.1 | 32 | 53.0 | 118 | 13.6 | 007 | DSSP 29 | 796 | 15 – 22 | SSC | 6.92 | | 1.40 | 75.6 |
| 81.0 | 32 | 51.5 | 118 | 16.2 | 007 | DSSP 30 | 1181 | 0 – 15 | SSC | 6.29 | | | |

Table F–1. Surface sediment samples (Continued).

| SAMPLE NO. | LATITUDE dd | mm.m | LONGITUDE ddd | mm.m | REF | SAMPLE ID | DEPTH m | INTERVAL cm | NAME | MEAN SIZE | MEDIAN SIZE | DENSITY g/cm | POROSITY % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MISCELLANEOUS (continued) | | | | | | | |
| 81.1 | 32 | 51.5 | 118 | 16.2 | 007 | DSSP 30 | 1181 | 15 – 22 | SSC | 6.32 | | 1.46 | 72.2 |
| 81.2 | 32 | 51.5 | 118 | 16.2 | 007 | DSSP 30 | 1181 | 40 – 47 | ClSa | 5.03 | | 1.61 | 64.5 |
| 81.3 | 32 | 51.5 | 118 | 16.2 | 007 | DSSP 30 | 1181 | 47 – 59 | SSC | 5.50 | | | |
| 82.0 | 32 | 52.6 | 118 | 19.2 | 007 | DSSP 34 | 915 | 0 – 7 | SiSa | 3.10 | | | |
| 92.0 | 32 | 57.5 | 118 | 17.0 | 007 | DSSP 51 | 1174 | 0 – 15 | SSC | 6.80 | | | |
| 92.1 | 32 | 57.5 | 118 | 17.0 | 007 | DSSP 51 | 1174 | 15 – 22 | SiCl | 9.10 | | 1.33 | 79.0 |
| 92.2 | 32 | 57.5 | 118 | 17.0 | 007 | DSSP 51 | 1174 | 40 – 47 | Cl | 9.71 | | 1.37 | 76.7 |
| 92.3 | 32 | 57.5 | 118 | 17.0 | 007 | DSSP 51 | 1174 | 50 – 60 | SiCl | 9.66 | | | |

**NOTE:** "REF" is reference (see text). "INTERVAL" is depth below seafloor in cm. "ClSi" is clayey silt, "SiCl" is silty clay, "SiSa" is silty sand; "SSC" is sand-silt-clay; "Sa" is sand; "Cl" is clay; "Si" is silt; "SaSi" is sandy silt; "SaCl" is sandy clay; and "ClSa" is clayey silt (these names follow Shepard, 1954). "MEAN" and "MEDIAN" are the mean and median sample grain sizes in phi units. "POROSITY" is the volume percent of pore space in the sample.

Table F–2. Rock samples.

| SAMPLE NO. | LATITUDE dd | mm.m | LONGITUDE ddd | mm.m | REF | SAMPLE ID | DEPTH m | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CRYSTALLINE AND VOLCANIC ROCKS | | |
| 1 | 33 | 30.4 | 118 | 48.0 | 001 | LCB 310–1 | 567 | Andesite |
| 2 | 33 | 29.6 | 118 | 54.5 | 001 | KSB 21A | 1000 | Basalt |
| 3 | 33 | 29.6 | 118 | 54.4 | 001 | KSB 21B | 1000 | Andesite |
| 4 | 33 | 29.6 | 118 | 54.4 | 001 | KSB 21F | 1000 | Volcanic agglomerate, andesite & basalt clasts |
| 5 | 33 | 16.7 | 118 | 55.4 | 001 | KSB 23A | 850 – 1350 | Actinolite epidotite, possibly altered anorthosite |
| 6 | 33 | 16.7 | 118 | 55.4 | 001 | KSB 23B | 850 – 1350 | Gabbro |
| 7 | 33 | 14.6 | 118 | 52.5 | 001 | KSB 33A | 490 – 750 | Diabase |
| 8 | 33 | 13.4 | 118 | 50.8 | 002 | D154 | | Volcanics (rotten) |
| 9 | 33 | 11.0 | 118 | 54.7 | 002 | CD148 | | Barite (?), volcanics, mudstone, quartzite |
| 10 | 33 | 17.6 | 118 | 55.8 | 002 | G143 | | Gabbro pebbles |
| | | | | | | SEDIMENTARY ROCKS | | |
| 11 | 33 | 29.6 | 118 | 54.4 | 001 | KSB 21E | 1000 | Breccia, clasts of mudstone & volcanic rocks |
| 12 | 33 | 15.1 | 118 | 8.7 | 001 | LCB 146–1 | 678 | Siltstone, moderately indurated |
| 13 | 33 | 14.6 | 118 | 9.8 | 001 | LCB 146–3 | 410 | Claystone |
| 14 | 33 | 4.6 | 118 | 35.4 | 001 | KZ 73–14–3 | 450 | Siltstone, moderately to poorly indurated |
| 15 | 33 | 3.9 | 118 | 37.1 | 001 | KZ 73–14–6 | 89 | Volcanic sandstone, calcite cement |
| 16 | 33 | 2.0 | 118 | 41.4 | 001 | KZ 73–14–14 | 465 | Siltstone |

**NOTE:** Sample numbers correspond to those plotted in Figure F–2. "REF" is reference (see text for references).

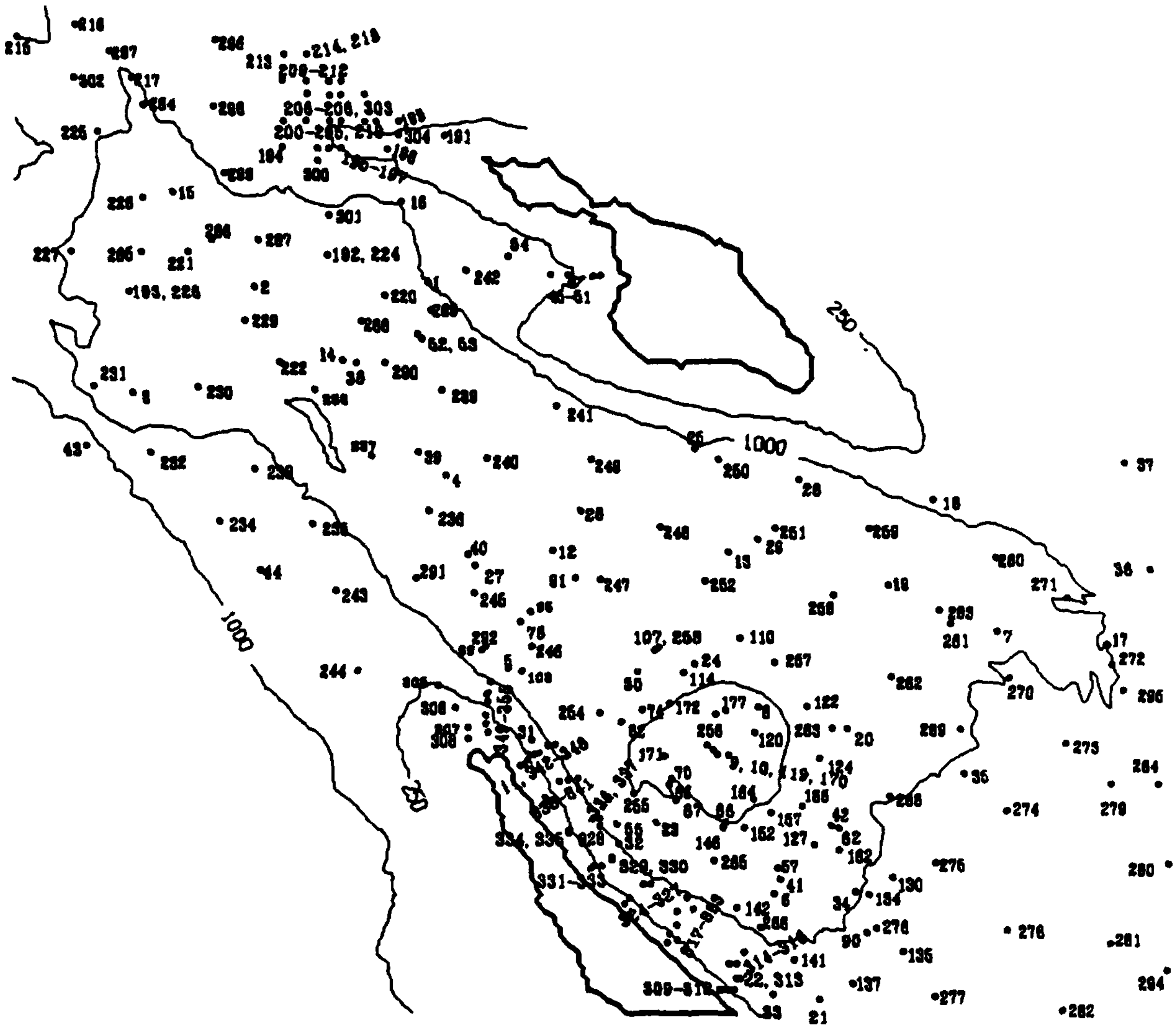


Figure F-1. Sediment sample locations, Catalina Basin.

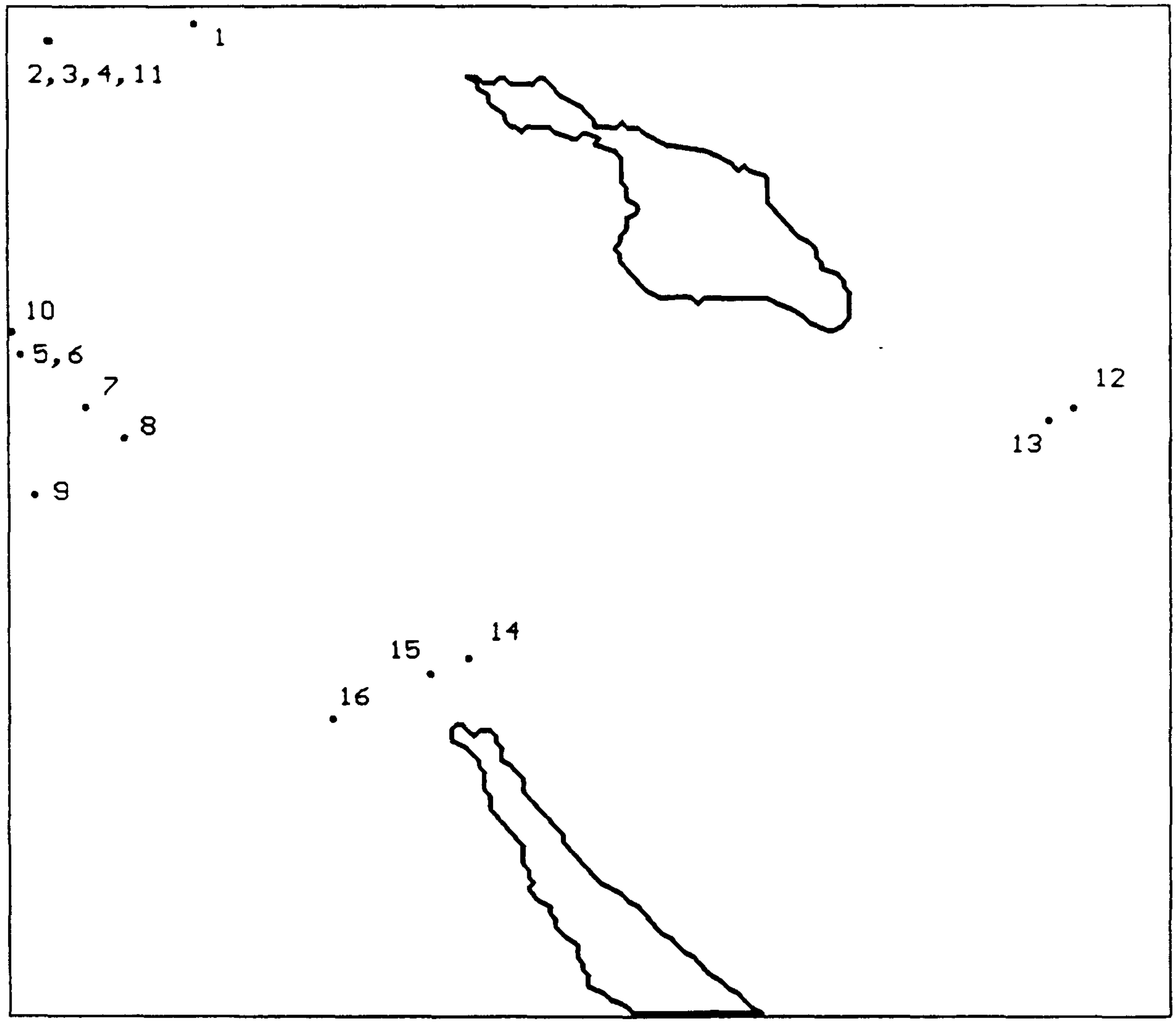


Figure F-2. Rock sample locations. Crystalline and volcanic (1 - 10) and sedimentary rock samples (11 - 16).

## REFERENCES (APPENDIX F)
## (OTHER THAN SAMPLE REFERENCES)

Shepard, F.P., 1954, Nomenclature Based on Sand-Silt-Clay Ratios; *J. Sediment. Petrol.*, 24:151-158.

# APPENDIX G: SEAWATER SOUND SPEED AND DENSITY

The temperature, salinity, and sound speed data in tables G-1 through G-4 were provided by A. Fisher, NRaD Code 742 (5 November 1992). I computed density from temperature, salinity, and depth. Sound speed profiles are illustrated in figure G-1. Tables G-1 through G-4 are reproduced as ASCII files on the accompanying disk (SSP.WIN, SSP.SPR, SSP.SMR, and SSP.FAL).

Table G-1. Winter seawater data: sound speed, temperature, salinity, and density.

| | | TEMPERATURE, °C | | SALINITY, ppt | | SOUND SPEED, m/s | | |
|---|---|---|---|---|---|---|---|---|
| DEPTH, m | n | MEAN | SIGMA | MEAN | SIGMA | MEAN | SIGMA | DENSITY, g/cm$^3$ |
| 0 | 2485 | 14.46 | 1.28 | 33.39 | 0.19 | 1503.6 | 4.1 | 1.0249 |
| 10 | 2485 | 14.36 | 1.28 | 33.39 | 0.18 | 1503.5 | 4.1 | 1.0249 |
| 20 | 2485 | 14.22 | 1.34 | 33.39 | 0.18 | 1503.2 | 4.3 | 1.0250 |
| 30 | 2485 | 14.01 | 1.45 | 33.40 | 0.18 | 1502.7 | 4.6 | 1.0251 |
| 50 | 2485 | 13.32 | 1.64 | 33.41 | 0.18 | 1500.7 | 5.3 | 1.0253 |
| 75 | 2484 | 11.98 | 1.65 | 33.46 | 0.20 | 1496.6 | 5.4 | 1.0258 |
| 100 | 2479 | 10.83 | 1.32 | 33.57 | 0.21 | 1493.2 | 4.3 | 1.0262 |
| 125 | 2455 | 10.05 | 0.99 | 33.72 | 0.20 | 1491.0 | 3.2 | 1.0265 |
| 150 | 2435 | 9.49 | 0.76 | 33.85 | 0.17 | 1489.5 | 2.5 | 1.0268 |
| 200 | 2361 | 8.71 | 0.58 | 34.02 | 0.11 | 1487.7 | 1.9 | 1.0273 |
| 250 | 2302 | 8.12 | 0.56 | 34.11 | 0.09 | 1486.4 | 1.9 | 1.0277 |
| 300 | 2249 | 7.58 | 0.57 | 34.15 | 0.09 | 1485.2 | 2.0 | 1.0281 |
| 400 | 2154 | 6.68 | 0.50 | 34.21 | 0.07 | 1483.4 | 1.8 | 1.0287 |
| 500 | 2026 | 6.00 | 0.42 | 34.27 | 0.06 | 1482.4 | 1.6 | 1.0293 |
| 600 | 957 | 5.39 | 0.37 | 34.33 | 0.06 | 1481.8 | 1.2 | 1.0299 |
| 800 | 524 | 4.53 | 0.27 | 34.42 | 0.04 | 1481.8 | 0.9 | 1.0310 |
| 1000 | 402 | 3.93 | 0.20 | 34.48 | 0.04 | 1482.6 | 0.9 | 1.0320 |
| 1200 | 132 | 3.42 | 0.31 | 34.52 | 0.04 | 1484.5 | 2.0 | 1.0330 |
| 1500 | 41 | 2.89 | 0.30 | 34.56 | 0.02 | 1486.5 | 1.3 | 1.0345 |

Table G-2. Spring seawater data: sound speed, temperature, salinity, and density.

| | | TEMPERATURE, °C | | SALINITY, ppt | | SOUND SPEED, m/s | | |
|---|---|---|---|---|---|---|---|---|
| DEPTH, m | n | MEAN | SIGMA | MEAN | SIGMA | MEAN | SIGMA | DENSITY, g/cm$^3$ |
| 0 | 3008 | 15.12 | 1.69 | 33.44 | 0.21 | 1505.8 | 5.3 | 1.0248 |
| 10 | 3008 | 14.82 | 1.63 | 33.43 | 0.21 | 1505.0 | 5.1 | 1.0249 |
| 20 | 3008 | 14.27 | 1.60 | 33.43 | 0.20 | 1503.4 | 5.1 | 1.0250 |
| 30 | 3008 | 13.68 | 1.74 | 33.44 | 0.21 | 1501.6 | 5.6 | 1.0252 |
| 50 | 3008 | 12.61 | 1.91 | 33.47 | 0.23 | 1498.3 | 6.2 | 1.0255 |
| 75 | 3008 | 11.43 | 1.76 | 33.54 | 0.26 | 1494.8 | 5.8 | 1.0259 |
| 100 | 3008 | 10.45 | 1.41 | 33.65 | 0.27 | 1491.9 | 4.6 | 1.0263 |
| 125 | 2965 | 9.74 | 1.01 | 33.77 | 0.24 | 1489.9 | 3.4 | 1.0266 |
| 150 | 2940 | 9.21 | 0.72 | 33.89 | 0.21 | 1488.5 | 2.4 | 1.0269 |
| 200 | 2860 | 8.50 | 0.51 | 34.04 | 0.13 | 1486.9 | 1.7 | 1.0274 |
| 250 | 2768 | 7.94 | 0.50 | 34.12 | 0.10 | 1485.7 | 1.8 | 1.0278 |
| 300 | 2711 | 7.43 | 0.51 | 34.16 | 0.09 | 1484.6 | 1.9 | 1.0281 |
| 400 | 2579 | 6.59 | 0.43 | 34.22 | 0.08 | 1483.0 | 1.6 | 1.0287 |
| 500 | 2392 | 5.95 | 0.35 | 34.28 | 0.06 | 1482.2 | 1.3 | 1.0293 |
| 600 | 907 | 5.36 | 0.31 | 34.33 | 0.05 | 1481.6 | 1.1 | 1.0299 |
| 800 | 408 | 4.50 | 0.24 | 34.41 | 0.04 | 1481.5 | 0.9 | 1.0310 |
| 1000 | 304 | 3.89 | 0.18 | 34.47 | 0.03 | 1482.3 | 0.9 | 1.0320 |
| 1200 | 120 | 3.39 | 0.28 | 34.52 | 0.03 | 1483.9 | 1.5 | 1.0330 |
| 1500 | 44 | 2.76 | 0.37 | 34.57 | 0.03 | 1487.1 | 3.0 | 1.0345 |

Table G-3. Summer seawater data: sound speed, temperature, salinity, and density.

| DEPTH, m | n | TEMPERATURE, °C MEAN | SIGMA | SALINITY, ppt MEAN | SIGMA | SOUND SPEED, m/s MEAN | SIGMA | DENSITY, g/cm³ |
|---|---|---|---|---|---|---|---|---|
| 0 | 1922 | 17.79 | 1.98 | 33.47 | 0.20 | 1513.9 | 5.9 | 1.0242 |
| 10 | 1922 | 17.26 | 1.95 | 33.46 | 0.20 | 1512.5 | 5.9 | 1.0243 |
| 20 | 1922 | 16.15 | 1.99 | 33.44 | 0.19 | 1509.2 | 6.2 | 1.0246 |
| 30 | 1922 | 15.00 | 2.18 | 33.43 | 0.19 | 1505.7 | 6.9 | 1.0249 |
| 50 | 1922 | 13.01 | 2.04 | 33.43 | 0.21 | 1499.6 | 6.7 | 1.0254 |
| 75 | 1922 | 11.52 | 1.74 | 33.51 | 0.24 | 1495.0 | 5.8 | 1.0259 |
| 100 | 1922 | 10.55 | 1.40 | 33.63 | 0.25 | 1492.2 | 4.7 | 1.0263 |
| 125 | 1882 | 9.84 | 1.03 | 33.75 | 0.23 | 1490.2 | 3.5 | 1.0266 |
| 150 | 1859 | 9.31 | 0.77 | 33.87 | 0.20 | 1488.9 | 2.6 | 1.0269 |
| 200 | 1816 | 8.62 | 0.61 | 34.04 | 0.13 | 1487.3 | 2.1 | 1.0274 |
| 250 | 1767 | 8.07 | 0.64 | 34.12 | 0.11 | 1486.2 | 2.2 | 1.0277 |
| 300 | 1727 | 7.56 | 0.68 | 34.17 | 0.10 | 1485.2 | 2.3 | 1.0281 |
| 400 | 1628 | 6.69 | 0.61 | 34.23 | 0.08 | 1483.5 | 2.1 | 1.0287 |
| 500 | 1507 | 6.03 | 0.47 | 34.28 | 0.06 | 1482.6 | 1.7 | 1.0293 |
| 600 | 594 | 5.43 | 0.42 | 34.34 | 0.06 | 1482.0 | 1.4 | 1.0299 |
| 800 | 327 | 4.54 | 0.30 | 34.42 | 0.05 | 1481.8 | 1.2 | 1.0310 |
| 1000 | 237 | 3.92 | 0.22 | 34.48 | 0.05 | 1482.5 | 1.0 | 1.0320 |
| 1200 | 73 | 3.44 | 0.22 | 34.53 | 0.05 | 1483.9 | 1.0 | 1.0330 |
| 1500 | 17 | 2.90 | 0.40 | 34.55 | 0.03 | 1486.5 | 1.7 | 1.0345 |

Table G-4. Autumn seawater data: sound speed, temperature, salinity, and density.

| DEPTH, m | n | TEMPERATURE, °C MEAN | SIGMA | SALINITY, ppt MEAN | SIGMA | SOUND SPEED, m/s MEAN | SIGMA | DENSITY, g/cm³ |
|---|---|---|---|---|---|---|---|---|
| 0 | 1566 | 17.10 | 1.93 | 33.47 | 0.18 | 1511.9 | 5.6 | 1.0243 |
| 10 | 1566 | 16.94 | 1.96 | 33.47 | 0.18 | 1511.6 | 5.7 | 1.0244 |
| 20 | 1566 | 16.40 | 2.04 | 33.46 | 0.17 | 1510.1 | 6.0 | 1.0246 |
| 30 | 1566 | 15.64 | 2.25 | 33.44 | 0.17 | 1507.8 | 6.8 | 1.0248 |
| 50 | 1566 | 13.53 | 2.23 | 33.40 | 0.18 | 1501.4 | 7.0 | 1.0253 |
| 75 | 1566 | 11.70 | 1.69 | 33.48 | 0.20 | 1495.7 | 5.4 | 1.0258 |
| 100 | 1566 | 10.63 | 1.39 | 33.61 | 0.20 | 1492.6 | 4.4 | 1.0262 |
| 125 | 1543 | 9.90 | 1.11 | 33.75 | 0.18 | 1490.6 | 3.4 | 1.0266 |
| 150 | 1532 | 9.37 | 0.90 | 33.87 | 0.16 | 1489.2 | 2.7 | 1.0269 |
| 200 | 1494 | 8.64 | 0.76 | 34.04 | 0.11 | 1487.5 | 2.2 | 1.0274 |
| 250 | 1456 | 8.08 | 0.74 | 34.12 | 0.10 | 1486.4 | 2.3 | 1.0277 |
| 300 | 1417 | 7.58 | 0.68 | 34.16 | 0.09 | 1485.3 | 2.5 | 1.0281 |
| 400 | 1311 | 6.71 | 0.57 | 34.23 | 0.07 | 1483.6 | 2.1 | 1.0287 |
| 500 | 1237 | 6.02 | 0.45 | 34.28 | 0.06 | 1482.5 | 1.6 | 1.0293 |
| 600 | 481 | 5.40 | 0.45 | 34.34 | 0.06 | 1481.9 | 1.5 | 1.0299 |
| 800 | 267 | 4.50 | 0.39 | 34.42 | 0.05 | 1481.9 | 1.7 | 1.0310 |
| 1000 | 203 | 3.86 | 0.33 | 34.48 | 0.05 | 1482.7 | 2.3 | 1.0320 |
| 1200 | 72 | 3.37 | 0.39 | 34.53 | 0.04 | 1484.4 | 2.4 | 1.0331 |
| 1500 | 30 | 2.76 | 0.44 | 34.57 | 0.04 | 1487.6 | 5.3 | 1.0345 |

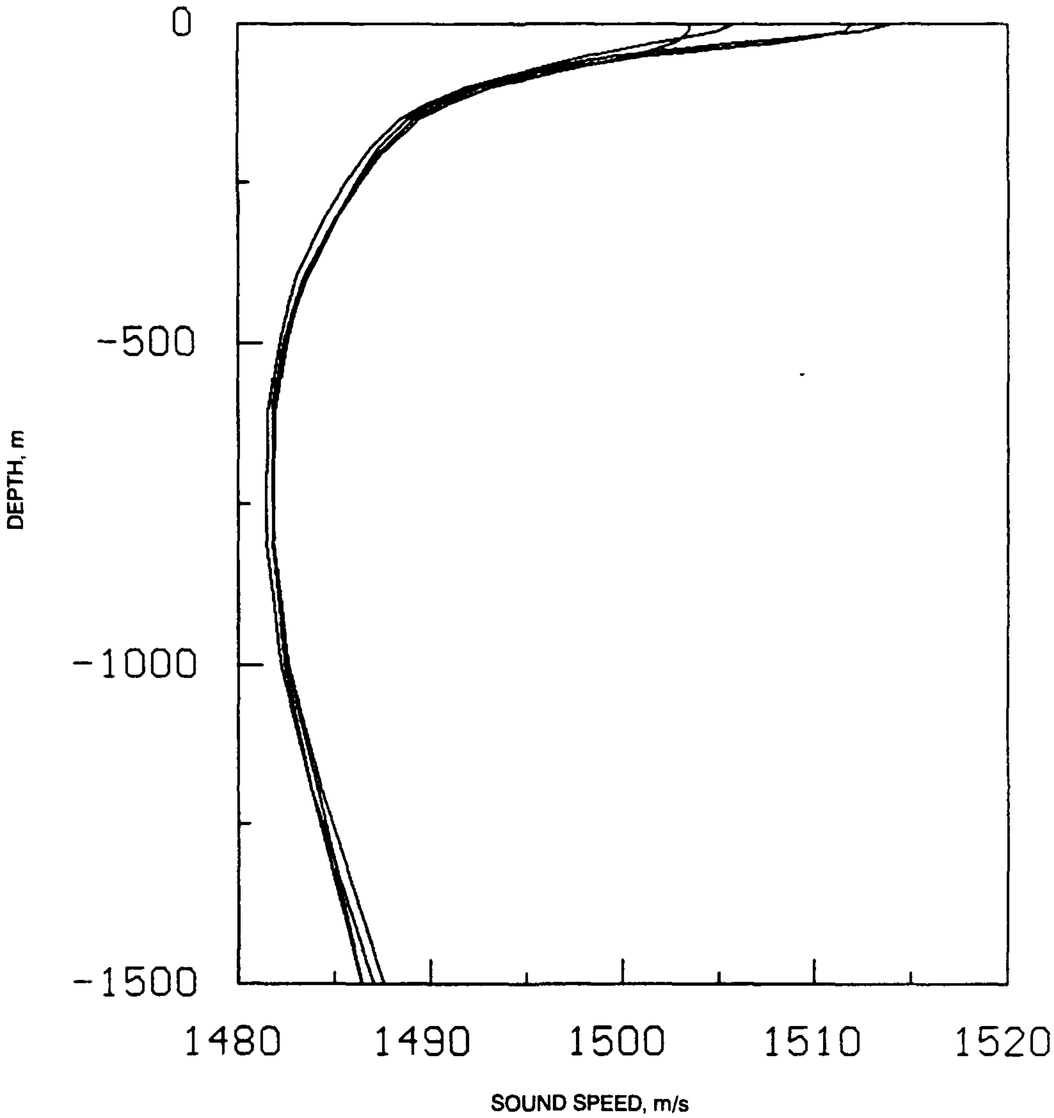


Figure G-1. Seasonal sound speed profiles.

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A three-dimensional database containing water depth, sediment thickness, surface and basement rock type, and surface sediment mean grain size is provided, which, when combined with generic sediment and rock geoacoustic properties (also provided) produces a geoacoustic description of the Catalina Basin. Mean grain size is used as an index to acoustic properties. The database is gridded at 15 seconds of latitude and longitude.

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